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Consulting Engineers and Geologists

REPORT ON SUPPLEMENTAL GEOTECHNICAL INVESTIGATION

PROJECT NO:	88612 AW
DESIGNATION:	Allen Park Clay Mine Hazardous Waste Disposal Cell
LOCATION:	Allen Park, Michigan
CLIENT:	Ford Motor Company
DATE:	July 7, 1989

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SUPPLEMENTAL GEOTECHNICAL INVESTIGATION
ALLEN PARK CLAY MINE
HAZARDOUS WASTE DISPOSAL CELL
ALLEN PARK, MICHIGAN

This report presents the results of a supplemental geotechnical investigation and slope stability analysis performed for the proposed Hazardous Waste Disposal Cell at the Allen Park Clay Mine in Allen Park, Michigan. The purpose of this supplemental investigation was to develop additional geotechnical data and to refine the previously performed slope stability analysis. The results of our investigation and subsequent analyses, together with our conclusions are documented herein. Authorization to perform this investigation was given through acceptance of our proposal dated October 18, 1988.

Previous Investigation

As part of the original preparation of the Construction Permit application for the Allen Park Clay Mine for Hazardous Cell II, NTH was retained by Ford to perform a geotechnical investigation. This previous investigation was performed in 1985 and consisted of the drilling of two soil borings, designated TB-1 and TB-2, and the installation of a pneumatic piezometer. The test borings were drilled from the prevailing ground surface at the northwest and southwest corners of the cell. During the drilling operations, a series of undisturbed samples as well as in-place soil strength tests (vane shear) were performed. Laboratory

testing of selected soil samples was also performed during this original investigation. The results of that investigation were presented in a report prepared by NTH entitled "Liner Engineering Report", dated March, 1988 and revised June 24, 1988.

Based on the results of the in-place soil strength testing and the laboratory soil testing performed for this original investigation, a generalized soil strength profile was developed and a short-term (or undrained) slope stability analysis was performed. Results of this slope stability analysis were included in the Liner Engineering Report.

Copies of the Logs of Test Boring for TB-1 and TB-2 as well as the associated laboratory and field test results developed during this previous investigation are included within this report in Appendix B.

Project Drawings

The Project Drawings entitled Allen Park Clay Mine Landfill-Hazardous Waste Disposal Site - Cell II prepared by Midwest Consulting, Inc. (MCI) were reviewed as part of our work for the supplemental geotechnical investigation. These drawings include cross-sections through the proposed cell showing the existing ground surface as well as the final cell configuration.

Based on our review of the MCI drawings, the cell floor elevation is presently approximately Elevation 563. The final bottom elevation is planned to be Elevation 567. The existing side slopes are at approximately 2 horizontal: 1 vertical (2:1). The proposed side slopes will be constructed at 4:1 slopes for approximately the lowest 12 feet of the cell, and 2:1 slopes above that. The existing top of slope elevation is approximately Elevation 594. In the final condition after completion of construction, the top of the berm shown on the MCI drawings will range from approximately Elevation 603 to 605.

MCI drawings show fill material in the solid waste management cells located immediately west and east of Cell II. It was reported by Ford personnel that these materials consist of slag sand and fly ash and industrial wastes from the Rouge Steel plant.

Field Investigation

During the period from January 13 through January 20, 1989 three test borings, designated TB-3 through TB-5, were drilled at the locations shown on the Test Boring Location Plan, Plate 1 in Appendix A. As shown on Plate 1, test borings TB-3 and TB-4 were drilled from the prevailing ground surface at the northeast and southeast corners of the cell, and test boring TB-5 was drilled from inside the cell in the northeast corner of the cell. The

locations of the test borings were chosen by Ford Motor Company in accordance with the scope of work outlined in the proposal for this investigation which was submitted to and verbally approved by the MDNR.

Test borings TB-3 and TB-4 were each drilled to a depth of approximately 90 feet below the ground surface, corresponding to approximately Elevation 505, and test boring TB-5 was drilled to a depth of approximately 58 feet below the ground surface of the cell, also corresponding to approximately Elevation 505. Boring locations and surface elevations were determined by Wayne Disposal Incorporated, (WDI). The coordinates and ground surface elevations at the test boring locations are presented on the Logs of Test Borings.

The test borings were drilled by American Drilling Company under the full-time supervision of a geotechnical engineer with our firm. The test borings were drilled with a truck-mounted rotary drilling rig utilizing 4-inch outside-diameter solid stem augers to a depth of 8.5 feet. Casing was then installed in the borehole and the boring continued utilizing wash rotary techniques.

Soil conditions encountered in the test borings have been evaluated and are presented in the form of Logs of Test Boring, Figures 1 through 3 in Appendix A. In addition, the boring logs

present information relating to sample data, standard penetration test results, water conditions observed in the borings, personnel involved and other pertinent data. For information and to aid in understanding the data as presented on the boring logs, General Notes defining nomenclature used in soil descriptions are presented in Plate 2. It should be noted that the logs included with this report have been prepared on the basis of laboratory classification and testing as well as field logs of the soils encountered.

For the supplemental study, soil samples were generally obtained at intervals of 5 feet. In general, the sampling procedure consisted of alternating piston samples with in-place strength tests (i.e. vane shear tests). However, a few soil samples were taken by the Standard Penetration Test (SPT) Method (ASTM D-1856), whereby a 2.0-inch outside-diameter split-barrel sampler is driven into the soil with a 140-pound weight falling freely through a distance of 30 inches. The sampler is generally driven three successive 6-inch increments, with the number of blows for each increment being recorded. The number of blows required to advance the sampler the last 12 inches is termed the Standard Penetration Resistance (N) and is presented graphically on the individual Logs of Test Boring for the samples where Standard Penetration Tests were performed. As added information, the blow counts for each 6-inch increment are also included on the logs where appropriate.

The primary purpose of the supplemental investigation, however, was to obtain detailed strength data of the subsoils at the site. For this reason, it was necessary to obtain undisturbed samples of the native soil using a hydraulically activated piston tube sampler. The procedure involves pushing a 3-inch outside-diameter thin-walled Shelby tube into the underlying soil and then withdrawing it with the enclosed cylinder of soil. After sampling, the ends of the Shelby tubes were cleaned and sealed with wax. Soil samples obtained in this manner are designated "PS" on the logs.

Vane shear tests were also performed in the soft subsoils at regular intervals. These tests were generally performed at alternate intervals to the piston samples. These tests were performed in accordance with the procedure outlined in ASTM D-2573.

The tests were performed by pushing a tapered vane into the soil a distance of 18-inches below the base of the bore hole. Torque was then applied to the vane until the surrounding soil was sheared. This torque was then measured and converted to a soil shear strength in accordance with ASTM Standards. This shear strength is included in the Vane Shear Reports, Figure Nos. 4 through 20 in Appendix A. The location of the individual vane shear test intervals at each test boring location have also been

included on the respective test boring logs. It should also be noted that the vane shear strengths have been adjusted in accordance with the procedure outlined in an article entitled "Embankments on Soft Ground", by Laurits Bjerrum as presented in the ASCE Conference on Performance of Earth and Earth Supported Structures, Volume II, June, 1972.

Laboratory Testing

Laboratory testing for this project consisted of the determination of the natural moisture content, in-place dry density, Atterberg limits and unconfined compressive strength of selected samples. The results of these laboratory tests are presented on the Tabulation of Test Data Sheets, Figure Nos. 21 and 22 in Appendix A. The natural moisture content and in-place dry density data shown in Figures 21 and 22 are also presented on the respective Logs of Test Boring.

Consolidated undrained (CU) triaxial tests with pore water pressure measurements were also performed on selected piston samples. These tests were performed in order to develop estimates of both the short and long term strength parameters of the soft clays present at this site. Each sample was initially consolidated to the in-situ overburden pressure, and was then subjected to an applied vertical load. Sample deformation and pore pressure measurements were recorded during the testing. The

results of these tests were then evaluated, and used to develop both total and effective stress parameters for the subsoils at the site. The results of the triaxial testing have been summarized and are presented on Figure 23 in Appendix A.

Additionally, two consolidation tests were performed to confirm the compressibility characteristics used to estimate settlement of the cell in the initial geotechnical analysis. The results of the consolidation tests are presented on Figure Nos. 24 and 25 in Appendix A, entitled Settlement versus Stress.

Subsoil Conditions

On the basis of the information developed during both the previous and current investigations, it appears that subsoil conditions throughout this site are reasonably uniform. At the present time, a fill deposit consisting of either brown to dark brown silty clay or medium compact brown to black silty sand and slag is present in test borings TB-1 through TB-4 to depths ranging from approximately 8 to 13.6 feet (Elevations 582 to 592). The stratigraphic sequence of the natural soil underlying the fill consists of a relatively thin layer of stiff lacustrine silty clay underlain by four glacial clay deposits. These clay deposits, in order of occurrence, consist of two medium gray silty clay formations, a stiff gray silty clay deposit and a hard gray silt clay to clayey silt locally termed hardpan. Underlying

the hardpan material, the native bedrock formation is encountered. These layers appear to be generally quite flat in the vicinity of the hazardous waste cell. However, the elevation at which the hardpan layer was encountered at the location of test boring TB-1 suggests a slight dip or anomaly in the top of the hardpan at that location.

Based on the subsurface information obtained in both investigations, the subsurface for the native soil was subdivided into five layers (4 through 8) and they are described below. For ease of reference, the native soil layers have been designated Layer 4 (lacustrine silty clay), Layers 5 and 6 (two medium silty clay layers), Layer 7 (stiff silty clay) and Layer 8 (hardpan). The fill deposits have been designated Layers 1 through 3, and are discussed in a later section of this report.

Design Layer 4 - At the locations of TB-3 and TB-4 a stiff lacustrine deposit is encountered beneath the fill, which extends to depths ranging from approximately 19 to 22 feet below the existing ground surface (Elevations 578 to 572). The test boring logs for of TB-1 and TB-2 do not identify the material below the fill in these borings as a lacustrine deposit. However, review of the laboratory data from TB-1 and TB-2 and from TB-3 and TB-4 indicates similar moisture contents in the soil immediately

below the fill for both sets of borings. It is believed that the material below the fill in TB-1 and TB-2 represent the same lacustrine deposit as is identified on the logs of TB-3 and TB-4.

<u>Design Layer 5</u> - Underlying the lacustrine deposit is a soft to medium gray silty clay deposit which contains a little to some sand and gravel. The clay deposit extends to depths of approximately 43 to 62 feet below the prevailing ground surface elevation, corresponding to Elevations 520 to 535.

<u>Design Layer 6</u> - The upper medium gray silty clay (Layer 5) is underlain by a somewhat different medium gray silty clay which extends to depths of 72 to 77 feet below the ground surface (Elevation 518 to 522) in TB-3, TB-4 and TB-5. Although this layer exhibits similar strength characteristics as the upper medium deposit, it contains somewhat more sand and exhibits somewhat less plasticity.

<u>Design Layer 7</u> - In TB-3 and TB-4, a layer of stiff gray silty clay underlies the medium gray silty clay deposits. This lower stiff layer is in turn underlain by hardpan. Review of the boring logs for TB-1 and TB-2 indicates that the standard penetration resistance for the soil directly above the hardpan was observed to range from 7 to 17 blows per foot for a distance of approximately 5 to 15 feet above the hardpan. These blow counts also correspond to a stiff consistency in cohesive soil.

The stiff gray silty clay encountered in TB-3 and TB-4 extends to depths of approximately 86 to 89 feet below the ground surface (Elevation 508 to 505).

<u>Design Layer 8</u> - The stiff gray silty clay was underlain by a very hard clayey silt to silty clay material locally termed hardpan. This material exhibits standard penetration resistance greater than 50 blows/foot.

<u>Groundwater Conditions</u>

A pneumatic piezometer was installed in the underlying bedrock aquifer within test boring TB-1 during our initial subsurface investigation at the site. Subsequent water level measurements indicated a piezometric elevation of approximately Elevation 605 within the bedrock aquifer. Artesian groundwater conditions were encountered in the hardpan layer during the drilling of both test boring TB-3 and TB-5. Boring TB-4 did not penetrate the hardpan and no groundwater was encountered in this boring. The results of the individual water level observations are shown on the respective Logs of Test Boring.

SELECTION OF DESIGN PARAMETERS

The results of the field and laboratory testing developed during our investigations of the site have been summarized and evaluated for the purpose of selecting design parameters for use in the slope stability analyses. The following paragraphs present the results of our evaluations and the corresponding design parameters.

<u>Index Properties</u> - For ease of reference, the results of the laboratory testing for soil index properties are presented graphically on Figure 26, Summary of Soil Index Properties. As shown on Figure 26, the measured values of total density, moisture content and Atterberg limits are presented for each soil layer at each test boring location. Review of Figure 26 indicates that within Layer 4, total soil density ranges from 115 to 134 pcf, moisture content ranges from 23 to 33 percent, liquid limits range from 24 to 38 percent, and plasticity indices range from 10 to 18 percent. Within Layer 5, total soil density ranges from 128 to 137 pcf, moisture content ranges from 18 to 22 percent, liquid limits range from 21 to 32 percent, and plasticity indices range from 7 to 15 percent. For Layer 6, total soil densities range from 126 to 136 pcf, moisture contents range from 22 to 24 percent, liquid limits range from 31 to 52 percent, and plasticity indices range from 13 to 26 percent, and

for Layer 7, total soil densities range from 117 to 129 pcf, moisture contents range from 22 to 32 percent, liquid limits range from 29 to 53 percent and plasticity indices range from 13 to 29 percent.

These values indicate consistent results across the site in all layers. Based on these test results, the following design parameters were selected.

Layer 4:	Density	=	124 pcf
	Moisture Content	=	29 %
Layer 5:	Density	=	133 pcf
	Moisture Content	=	21 %
Layer 6:	Density	=	130 pcf
	Moisture Content	=	23 %
Layer 7:	Density	=	128 pcf
	Moisture Content	=	25 %

Undrained Shear Strength - The results of the vane shear testing and unconfined compressive strength testing performed at the site are summarized on Figures 21 and 22, Summary of Laboratory Data, as well as on Figures 4 through 20, Vane Shear Test Results. Review of these test results from Test borings TB-1 through TB-4 indicate undrained shear strengths ranging from 553 to 1115 psf in Layer 4, ranging from 580 to 846 psf in Layer 5, and ranging from 218 to 924 psf in Layer 6. One vane shear value of 1241 psf was obtained from Layer 7. With the exception of one low shear vane test value in Layer 6 (i.e., 218 psf at the location of test boring TB-3), the remainder of the test results for test borings TB-1 through TB-4 show good agreement across the site.

While index properties tests from borings TB-1 through TB-5 and the triaxial test data indicate uniformity in soil characteristics across the site, the results of the vane shear testing performed in test boring TB-5 are lower than the values recorded in test borings TB-1 through TB-4 for both layers tested. At the location of TB-5 within Layer 5, undrained shear strengths range from 208 to 341 psf and within Layer 6, shear strengths ranging from 186 to 465 psf were recorded. No vane shear tests were performed in Test Boring TB-5 in Layer 7.

Some reduction in shear strengths at the location of test boring TB-5 may be expected due to the lower overburden pressure at the location of TB-5. The shear strength of soil is directly

proportional to the overburden pressure. In the vicinity of test boring TB-5, the cell has been excavated, such that the existing overburden is approximately 30 feet lower than the prevailing ground surface elevation. Therefore, we would expect the soil strengths under the floor of the cell to be lower than the soil strengths under the sides of the cell. The vane shear test generally measures available in-situ shear strength which is a function of the available overburden pressure.

However, considering the consistency of index properties and triaxial test data across the site we believe that the shear strength measured by the vane shear test may also be low due to a malfunction of the vane shear device during field operations.

We do not believe that the lower shear strengths recorded at the location of test boring TB-5 are significant with respect to the stability of the cell. The results of our slope stability analysis, presented in a later section of this report, indicate that the critical slope failure surfaces are located under the sides of the cell. Therefore, the shear strength of the native subsoils contributing to the stability of the slopes are best represented by the results of soil testing performed on samples from TB-1 through TB-4.

We therefore selected undrained shear strength parameters, after accounting for sampling disturbance, for use in the slope

stability analysis based on the results of the vane shear and unconfined compressive strength test results from the relevant test borings TB-1 through TB-4 as follows:

Layer 4:	c = 880 psf
Layer 5:	c = 880 psf
Layer 6:	c = 880 psf
Layer 7:	c = 3000 psf

Triaxial Shear Strength Results - The results of the triaxial shear strength results are presented in Figure 23, Summary of Triaxial Shear Strengths. These results were evaluated in accordance with the method presented by Lambe and Whitman in their text entitled "Soil Mechanics". This diagram represents various states of stress for a given soil, and allows a comparison of the cohesion values obtained for the various samples during the triaxial testing with an adjustment for the overburden stress of each individual sample.

For a p-q diagram, the peak points of the stress-strain curves from triaxial tests (or p and q at failure) are plotted. A curved line can be drawn through these points; this curve can be approximated by a straight line over the stress range of interest. The equation of the straight line can then be obtained from the slope and intercept, and the shear strength is represented as a function of vertical pressure.

Using the p-q test results, we developed both effective and total parameters for the slope stability analysis. Based on the test results, the native soils at the site exhibit both cohesive and frictional strength in both the drained (effective stress) and undrained (total stress) conditions.

For design purposes, we have selected the following shear strength parameters for each layer.

Layer 5: Effective Stress Parameters

$c' = 0$ psf
$\phi' = 24\,^\circ$

Total Stress Parameters

$c = 850$ psf
$\phi = 8\,^\circ$

Layer 6: Effective Stress Parameters

$c' = 0$ psf
$\phi' = 24\,^\circ$

Total Stress Parameters

$c = 540$ psf
$\phi = 12\,^\circ$

Layer 7: Effective Stress Parameters

$c' = 0$ psf
$\phi' = 35\,^\circ$

Total Stress Parameters

$c = 3000$ psf
$\phi = 0\,^\circ$

It should also be noted that the stiff gray silty clay (Layer 7) is underlain by a very hard clayey silt to silty clay material locally termed hardpan. This material has standard penetration resistance greater than 50 blows/foot. For design purposes, the hardpan was assigned a cohesion value of 10,000 psf.

Design Configuration

Review of the design drawings prepared by MCI prompted the development of two different design configurations for slope stability analysis. Review of Section A-A on sheet 11 of the MCI drawings indicates that the east and west sides of Cell II have slightly different configurations.

East Side - The configuration of the east side of Cell II is presented on Plates 3B, 4B and 5B. Review of these plates indicates that the east side of Cell II contains a compacted clay berm located adjacent to the non-hazardous waste cell. The berm is underlain by native soil.

West Side - The configuration of the west side of Cell II is presented on Plates 3A, 4A and 5A. These plates indicate that the west side of Cell II contains a compacted clay berm located immediately adjacent to solid waste fill and supported on a thin fill layer. This lower fill layer is underlain by native soil.

The selection of design parameters for the upper fill materials are discussed below.

Fill Material

Layer 1 consists of compacted clay fill for the liner and stabilization berm. Design parameters for use in the slope stability analysis were selected from the APCM Liner Engineering Report. The parameters utilized for design include total density of 130 pcf, cohesion of 2500 psf, and friction angle of zero. Layer 2 consists of landfill material in the adjacent cell. This material consists of industrial wastes such as slag sand and fly ash. For design purposes, it has been assumed that this fill material has a total density of 125 pcf, an angle of internal friction of 25 degrees and no cohesion. Layer 3 consists of fill material encountered at the top of the compacted clay berms during the current and previous subsurface investigations. This material consists of silty clay with traces of brick and concrete fragments. For design purposes, this layer has been assigned a total density of 130 pcf, cohesion of 1000 psf and $\phi = 0$.

SUMMARY OF DESIGN PROFILES

A summary of the design profiles for the undrained ($\phi = 0$), as well as total stress parameters are presented in Tables 1 and 2 below:

TABLE 1

DESIGN UNDRAINED STRENGTH PARAMETERS

Layer	Description	Total Density (pcf)	Cohesion (psf)	Angle of Internal Friction-ϕ
1	Compacted Clay Liner	130	2500	0°
2	Solid Waste Fill Slag Sand and Fly Ash	125	0	25°
3	Clay Berm	130	1000	0°
4	Stiff Gray Silty Clay	130	880	0°
5	Medium Gray Silty Clay	130	880	0°
6	Medium Gray Silty Clay	130	880	0°
7	Stiff Gray Silty Clay	128	3000	0°
8	Hardpan	130	10,000	0°

TABLE 2

DESIGN STRENGTH PARAMETERS
TOTAL STRESS ANALYSIS

Layer	Description	Total Density (pcf)	Cohesion (psf)	Angle of Internal Friction-ϕ
1	Compacted Clay Liner	130	2500	0°
2	Solid Waste Fill Slag Sand and Fly Ash	125	0	25°
3	Clay Berm	130	1000	0°
4	Stiff Gray Silty Clay	124	650	10°
5	Medium Gray Silty Clay	133	650	10°
6	Medium Gray Silty Clay	130	500	12°
7	Stiff Gray Silty Clay	128	3000	0°
8	Hardpan	130	>10,000	0°

A summary of the design profile for the effective stress (drained) condition is presented in Table 3 below.

TABLE 3

DESIGN STRENGTH PARAMETERS
EFFECTIVE STRESS ANALYSIS

Layer	Description	Total Density (pcf)	Cohesion (psf)	Angle of Internal Friction-ϕ
1	Compacted Clay Liner	130	2500	0°
2	Solid Waste Fill Slag Sand and Fly Ash	125	0	25°
3	Clay Berm	130	0	25°
4	Stiff Gray Silty Clay	124	250	24°
5	Medium Gray Silty Clay	133	250	24°
6	Medium Gray Silty Clay	130	350	24°
7	Stiff Gray Silty Clay	128	0	35°
8	Hardpan	130	>10,000	>35°

SLOPE STABILITY

It is important to note that the total shearing strength of a soil is defined as $s = c + p' \tan \phi$; where c is the cohesion or undrained shear strength of the soil, p' is the effective overburden pressure of the soil, and ϕ is the angle of internal

friction of the soil. When a soil is initially loaded such that excess pore pressure is induced, the apparent strength of the soil is characteristic of the total shearing strength, i.e.,it exhibits both cohesive and frictional strength. With time, however, the excess pore pressure dissipates, and the soil behaves as an essentially frictional material. Therefore, a slope stability analysis needs to include an analysis of both total strength short-term parameters and an effective strength (long-term) parameters. In addition, we examined the case of undrained (ϕ = 0) conditions.

The stability of the two different design sections were evaluated using both drained and undrained strength parameters. The analysis was performed using a computer program entitled "PC-Slope" which was developed by Geo-Slope Programming Ltd. This software will search for the critical failure surface once the limits of the failure surface are defined. By varying the initiation and termination points of the failure surface, the critical circle for each design profile was located and the corresponding factor of safety defined. The program determines a factor of safety based on the ordinary Bishop and Janbu Methods. The factor of safety based on the Janbu Method of analysis, which is the most conservative, was used for this analysis.

Our analysis also incorporated a construction surcharge of 1000 psf applied to the dike on the east and west sides for a short-

term drainage condition. This surcharge is intended to simulate loading on the haul road during construction of the cell. In addition, a surcharge of 1000 psf was applied to the east side of the cell for long-term drained stability conditions. This surcharge loading is intended to simulate truck loading on the haul road during filling of the cell.

Results of the Slope Stability Analysis

The slope stability analysis of Cell II was performed for the two different surface configurations (i.e. east side and west side) based on the design strength parameters presented previously. In addition, the design configuration included the confining berms planned for installation around the perimeter of the toe of the cell side slopes.

The results of the stability analysis are tabulated below.

SUMMARY OF FACTORS OF SAFETY

East Side	Factor of Safety
Undrained - ($\phi = 0$)	1.4
Total Stress	1.7
Effective Stress	1.7

West Side

Undrained - ($\phi = 0$)	1.2
Total Stress	1.3
Effective Stress	1.5

The results of this investigation indicate that the computed factors of safety against failure of the side slopes of Cell I for both short term and long term drainage conditions are adequate for the proposed Hazardous Waste Cell II, based upon construction of the proposed confining berms.

As shown above the lowest safety factor occurs on the west side of the cell for the undrained condition. We believe this value is impacted by the 1000 psf surcharge assumed to exist during the construction condition. While this safety factor is adequate, it may be advisable to maintain traffic on the outside of the berm, away from the edge of the cell, during construction of the cell.

SETTLEMENT ANALYSIS

In conjunction with the original geotechnical investigation performed for the operating license application, one consolidation test was performed, and a settlement analysis for the cell was performed. To confirm the consolidation design parameters used in the original settlement analysis, two

additional consolidation tests were performed in conjunction with the current investigation. The results of these two additional consolidation tests are presented on Figure Nos. 24 and 25.

Review of these figures indicates that the preconsolidation pressure Pc computed for the current investigation is about 1.7 tsf, and the compression index Cc' ranges from 0.090 to 0.10 inches per inch (in/in). The recompression index Cr' is 0.020 in/in. For the initial settlement analysis, Pc values of about 2.5 tsf, a Cc' value of 0.138 in/in and a Cr' value of 0.026 in/in were used.

The Pc values determined from the present investigation appear to be smaller than those developed in the previous investigation. We have therefore recomputed the estimated maximum and minimum total settlements that may occur under the liner of Cell II.

The results of our settlement analysis indicate an estimated maximum total settlement of approximately 1.4 feet under the center of the cell, and an estimated minimum total settlement of approximately 8 inches under the edge of the cell. These values correspond to an estimated maximum differential settlement of 10 inches which is expected to occur over approximately 300 feet. The major impact of this settlement is expected to be a slight flattening of the hydraulic gradient in the leachate collection system.

We have also analyzed the effect of this differential settlement on the structural integrity of the pipe planned for installation in the leachate collection system. Based on our analysis, this amount of differential settlement is not expected to structurally damage the pipes.

Very truly yours,

NEYER, TISEO & HINDO, LTD.

Laurel A. Kendall

Laurel A. Kendall, P.E.
Project Manager

Sherif S. Afifi /H

Sherif S. Afifi, P.E.
Geoenvironmental Department Manager

CJG/SSA/sew

APPENDIX A

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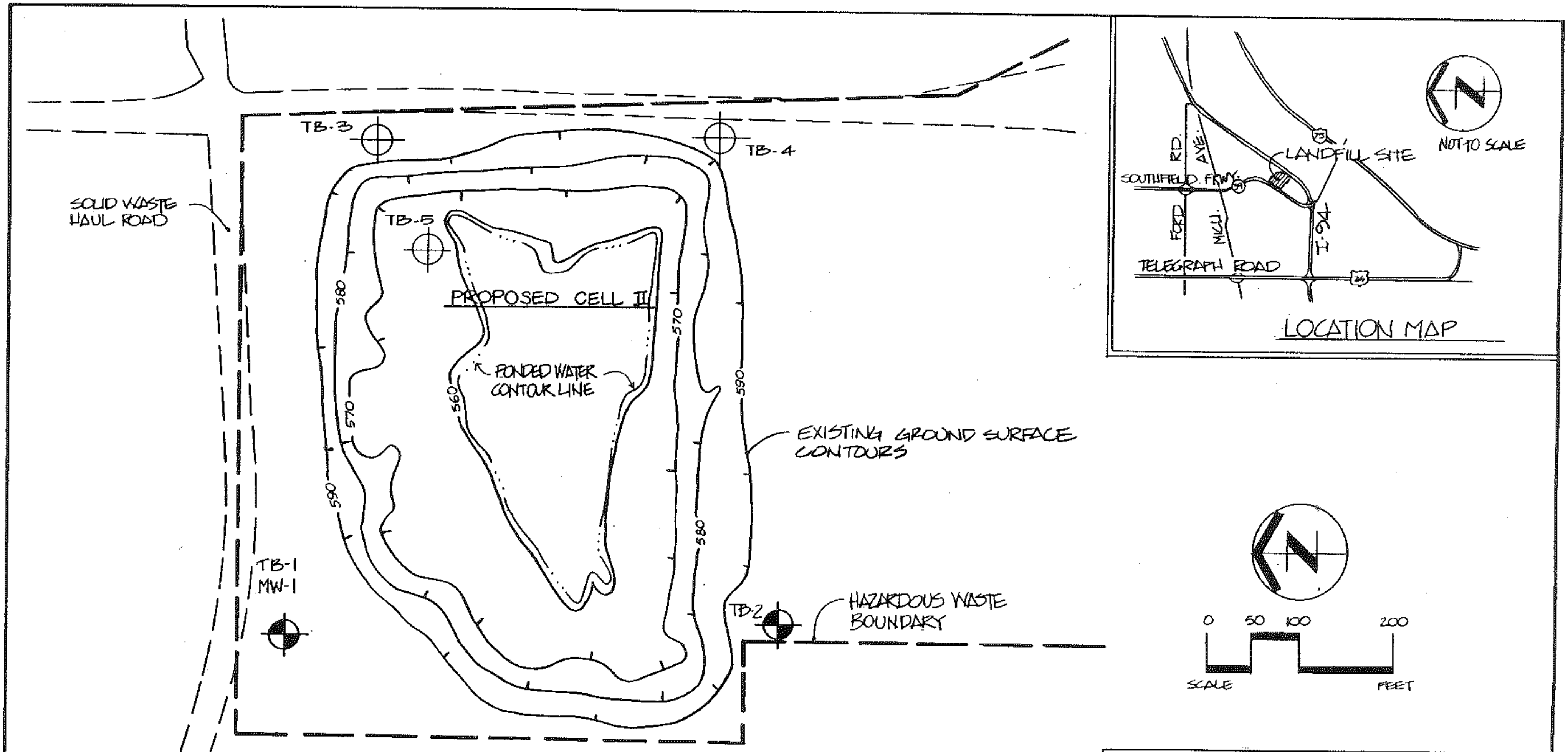


LEGEND:

TB — TEST BORING BY AMERICAN DRILLING CO. UNDER THE FULL TIME SUPERVISION OF NEYER, TISEO & HINDO, LTD. ON DEC. 20, 21 AND 26, 1984. TEMPORARY GROUNDWATER OBSERVATION WELL INSTALLED IN TB-1.

TEST BORING BY AMERICAN DRILLING CO. UNDER THE FULL TIME SUPERVISION OF NTH CONSULTANTS, LTD. ON JAN. 13-16, 1989.

NOTES:

1) TEST BORING LOCATIONS SHOWN ARE APPROXIMATE

TEST BORING LOCATION PLAN

ALLEN PARK CLAY MINE LANDFILL
FORD MOTOR COMPANY
ALLEN PARK, MICHIGAN

NTH NEYER, TISEO & HINDO, LTD.
CONSULTING ENGINEERS
30999 TEN MILE RD. · FARMINGTON HILLS, MI 48024

PROJECT NO. 88612 AW	DRAWN BY: MWW	DATE: 6/89
SCALE: AS SHOWN	CHECKED BY: LK	SHEET 1 OF 1

PLATE 1

NEYER, TISEO & HINDO, LTD.

GENERAL NOTES

TERMINOLOGY

Unless otherwise noted, all terms utilized herein refer to the Standard Definitions presented in ASTM D 653.

PARTICLE SIZES

Boulders		-	Greater than 12 inches (305mm)
Cobbles		-	3 inches (76.2mm) to 12 inches (305mm)
Gravel	Coarse	-	3/4 inches (19.05mm) to 3 inches (76.2mm)
	Fine	-	No. 4 - 3/16 inches (4.75mm) to 3/4 inches (19.05mm)
Sand	Coarse	-	No. 10 (2.00mm) to No. 4 (4.75mm)
	Medium	-	No. 40 (0.425mm) to No. 10 (2.00mm)
	Fine	-	No. 200 (0.074mm) to No. 40 (0.425mm)
Silt		-	0.005mm to 0.074mm
Clay		-	Less than 0.005mm

COHESIONLESS SOILS

Classification

The major soil constituent is the principal noun, i.e. sand, silt, gravel. The second major soil constituent and other minor constituents are reported as follows:

Second Major Constituent (percent by weight)	Minor Constituents (percent by weight)
Trace - 1 to 12%	Trace - 1 to 12%
Adjective - 12 to 35% (clayey, silty, etc.)	Little - 12 to 23%
And - Over 35%	Some - 23 to 33%

Density Classification	Relative Density %	Approximate Range of (N)
Very Loose	0-15	0-4
Loose	16-35	5-10
Medium Compact	36-65	11-30
Compact	66-85	31-50
Very Compact	86-100	Over 50

Relative Density of Cohesionless Soils is based upon the evaluation of the Standard Penetration Resistance (N), modified as required for depth effects, sampling effects, etc.

COHESIVE SOILS

If clay content is sufficient so that clay dominates soil properties, clay becomes the principal noun with the other major soil constituent as modifier; i.e., silty clay. Other minor soil constituents may be included in accordance with the classification breakdown for cohensionless soils; i.e., silty clay, trace of sand, little gravel.

Consistency	Unconfined Compressive Strength (psf)	Appromixate Range of (N)
Very Soft	Below 500	0-2
Soft	500-1000	3-4
Medium	1000-2000	5-8
Stiff	2000-4000	9-15
Very Stiff	4000-8000	16-30
Hard	8000-16000	31-50
Very Hard	Over 16000	Over 50

Consistency of cohesive soils is based upon an evaluation of the observed resistance to deformation under load and not upon the Standard Penetration Resistance (N).

SAMPLE DESIGNATIONS

- AS - Auger Sample - Directly from auger flight.
- BS - Miscellaneous Samples - Bottle or Bag.
- S - Split Spoon Sample with Liner Insert - ASTM D 1586
- LS - Liner Sample S with liner insert 3 inches in length.
- ST - Shelby Tube Sample - 3 inch diameter unless otherwise noted.
- PS - Piston Sample - 3 inch diameter unless otherwise noted.
- RC - Rock Core - NX core unless otherwise noted.

STANDARD PENETRATION TEST (ASTM D 1586) - A 2.0" outside-diameter, 1-3/8" inside-diameter split barrel sampler is driven into undisturbed soil by means of a 140-pound weight falling freely through a vertical distance of 30 inches. The sampler is normally driven three successive 6-inch increments. The total number of blows required for the final 12 inches of penetration is the Standard Penetration Resistance (N).

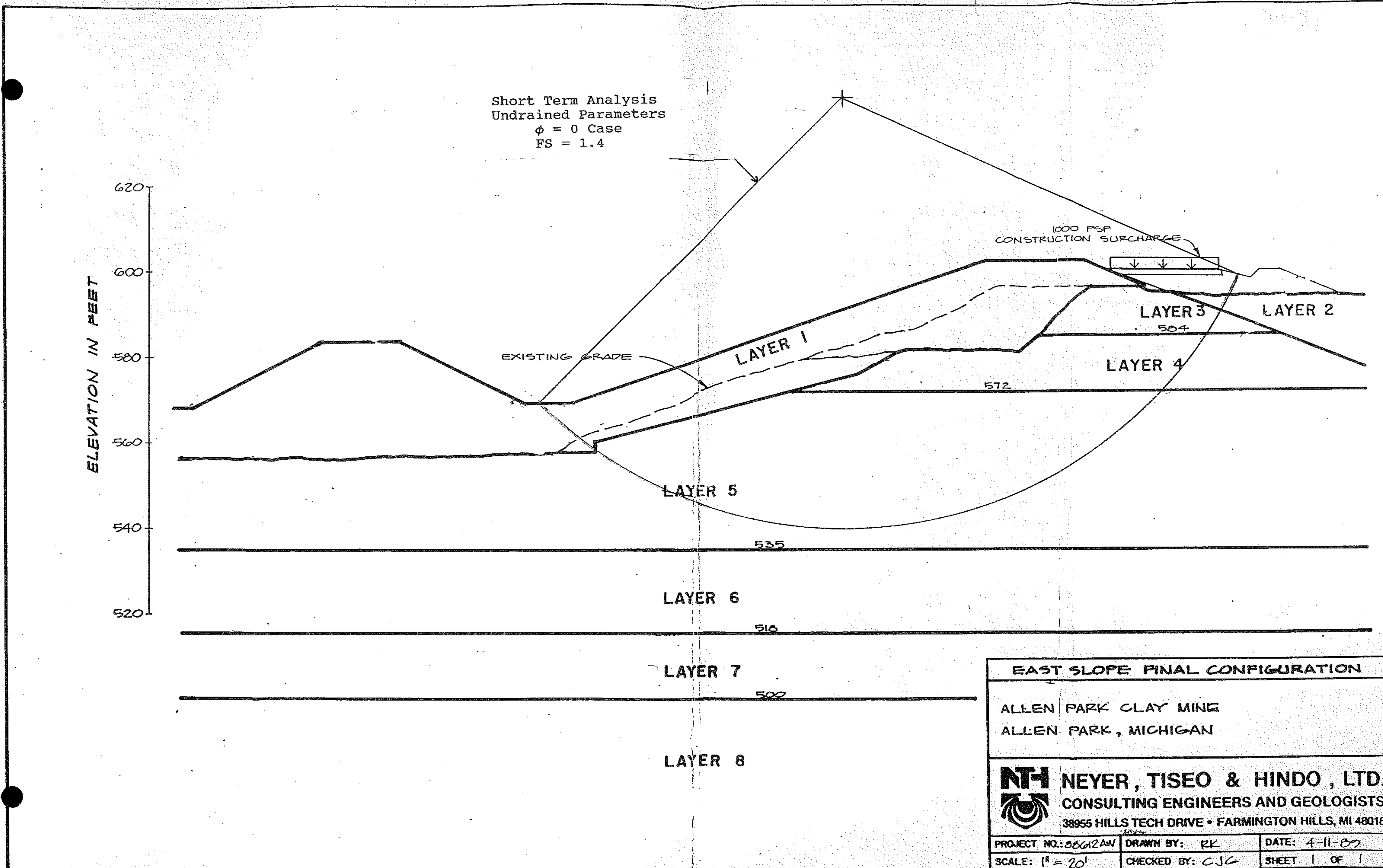
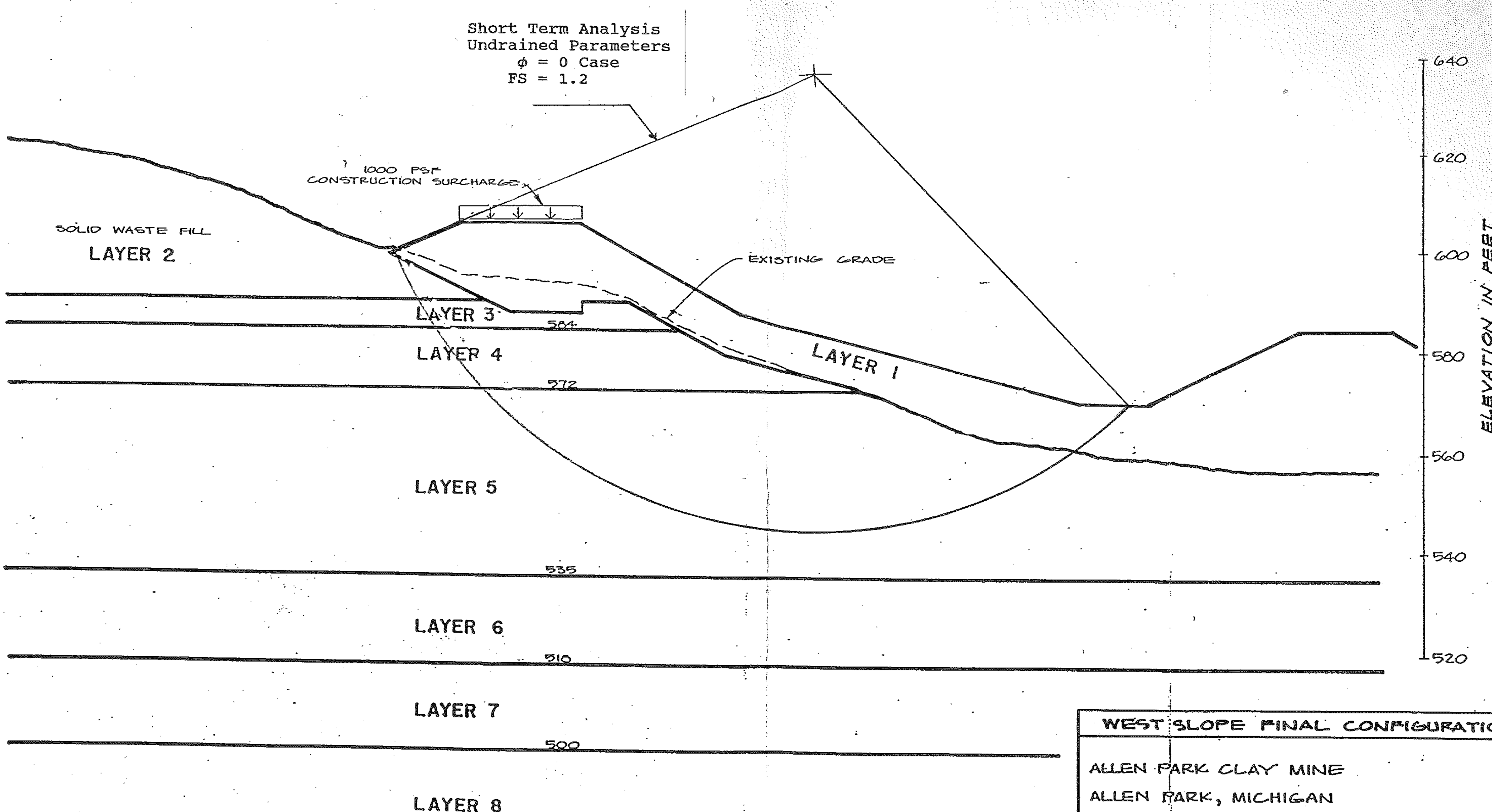

Short Term Analysis
Undrained Parameters
ϕ = 0 Case
FS = 1.4
1000 PSF
CONSTRUCTION SURCHARGE
ELEVATION IN FEET
620
600
580
560
540
520
EXISTING GRADE
LAYER 1
LAYER 3
LAYER 2
584
LAYER 4
572
LAYER 5
535
LAYER 6
516
LAYER 7
500
LAYER 8
EAST SLOPE FINAL CONFIGURATION
ALLEN PARK CLAY MINE
ALLEN PARK, MICHIGAN
NTH
NEYER, TISEO & HINDO, LTD.
CONSULTING ENGINEERS AND GEOLOGISTS
38955 HILLS TECH DRIVE • FARMINGTON HILLS, MI 48018
PROJECT NO.: 88612AW
DRAWN BY: RK
DATE: 4-11-89
SCALE: 1" = 20'
CHECKED BY: CJG
SHEET 1 OF 1

PLATE 3A



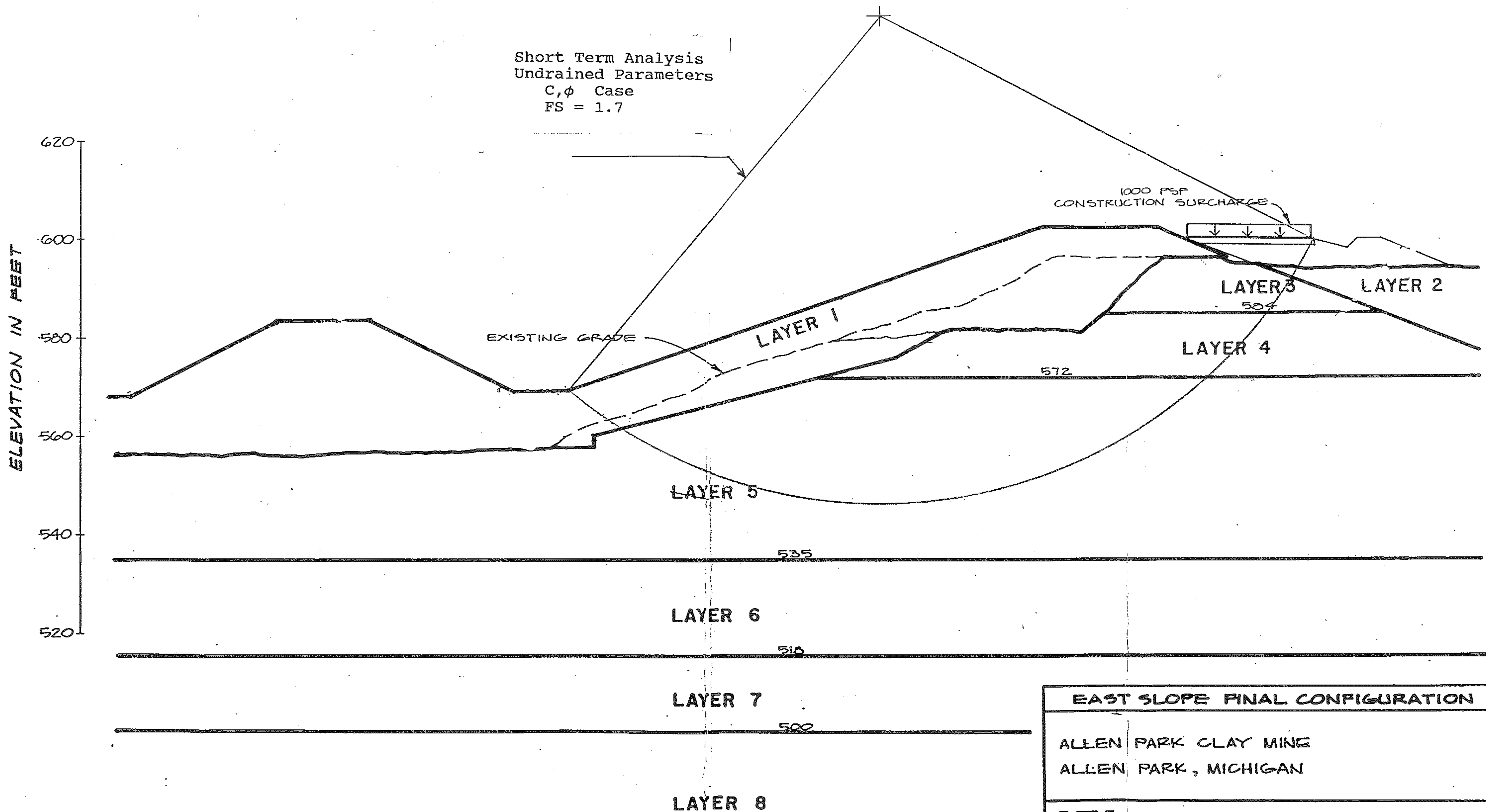
WEST SLOPE FINAL CONFIGURATION

ALLEN PARK CLAY MINE
ALLEN PARK, MICHIGAN

NEYER, TISEO & HINDO, LTD.
CONSULTING ENGINEERS AND GEOLOGISTS
38955 HILLS TECH DRIVE • FARMINGTON HILLS, MI 48018

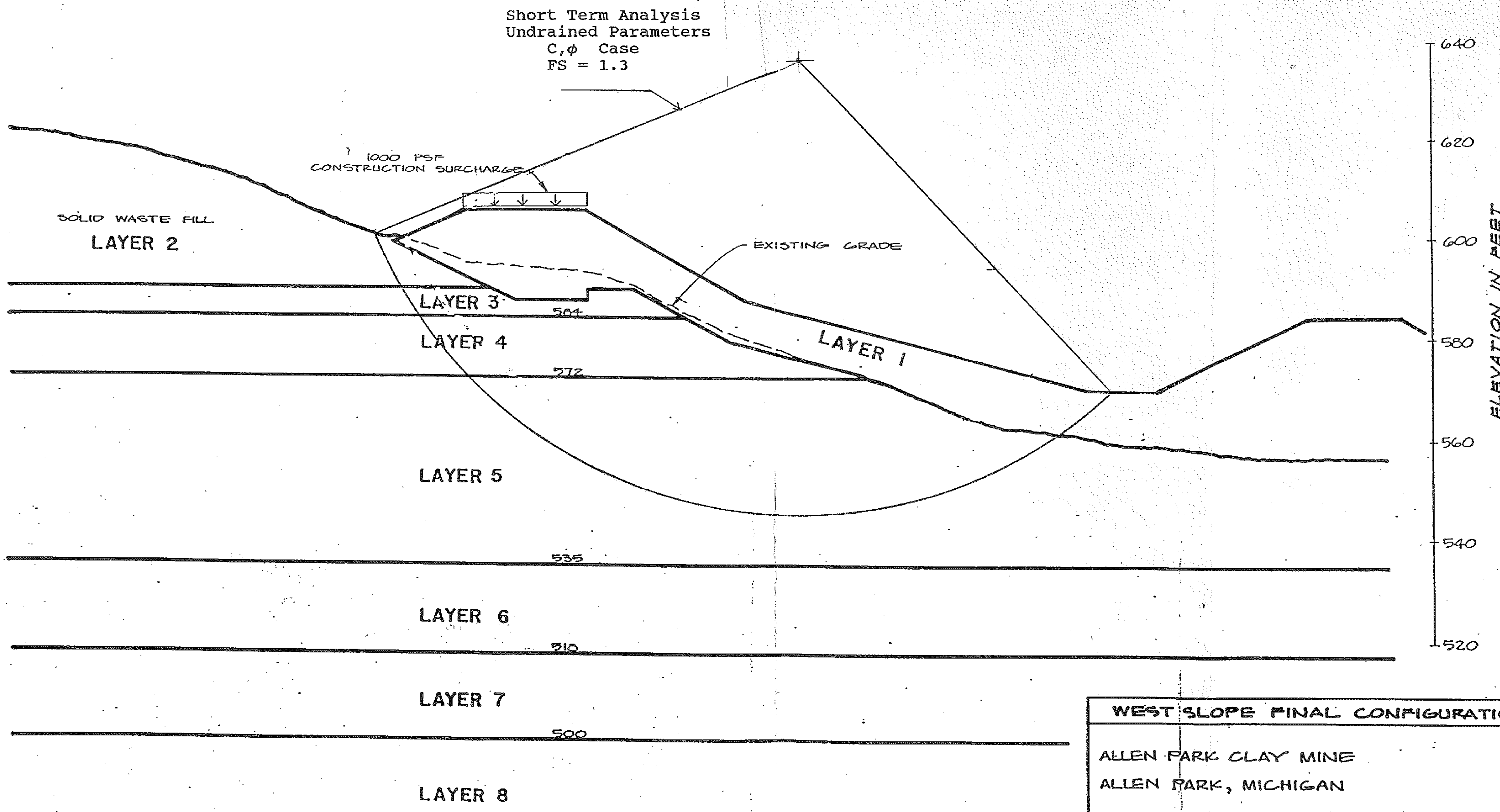
PROJECT NO.: 88612 AW	DRAWN BY: RK	DATE: 4-11-89
SCALE: 1" = 20'	CHECKED BY: CJG	SHEET 1 OF 1

PLATE 3B



EAST SLOPE FINAL CONFIGURATION		
ALLEN PARK CLAY MINE ALLEN PARK, MICHIGAN		
NEYER, TISEO & HINDO, LTD. CONSULTING ENGINEERS AND GEOLOGISTS 38955 HILLS TECH DRIVE • FARMINGTON HILLS, MI 48018		
PROJECT NO.: 88612AW	DRAWN BY: RK	DATE: 4-11-89
SCALE: 1" = 20'	CHECKED BY: CJG	SHEET 1 OF 1

PLATE 4A



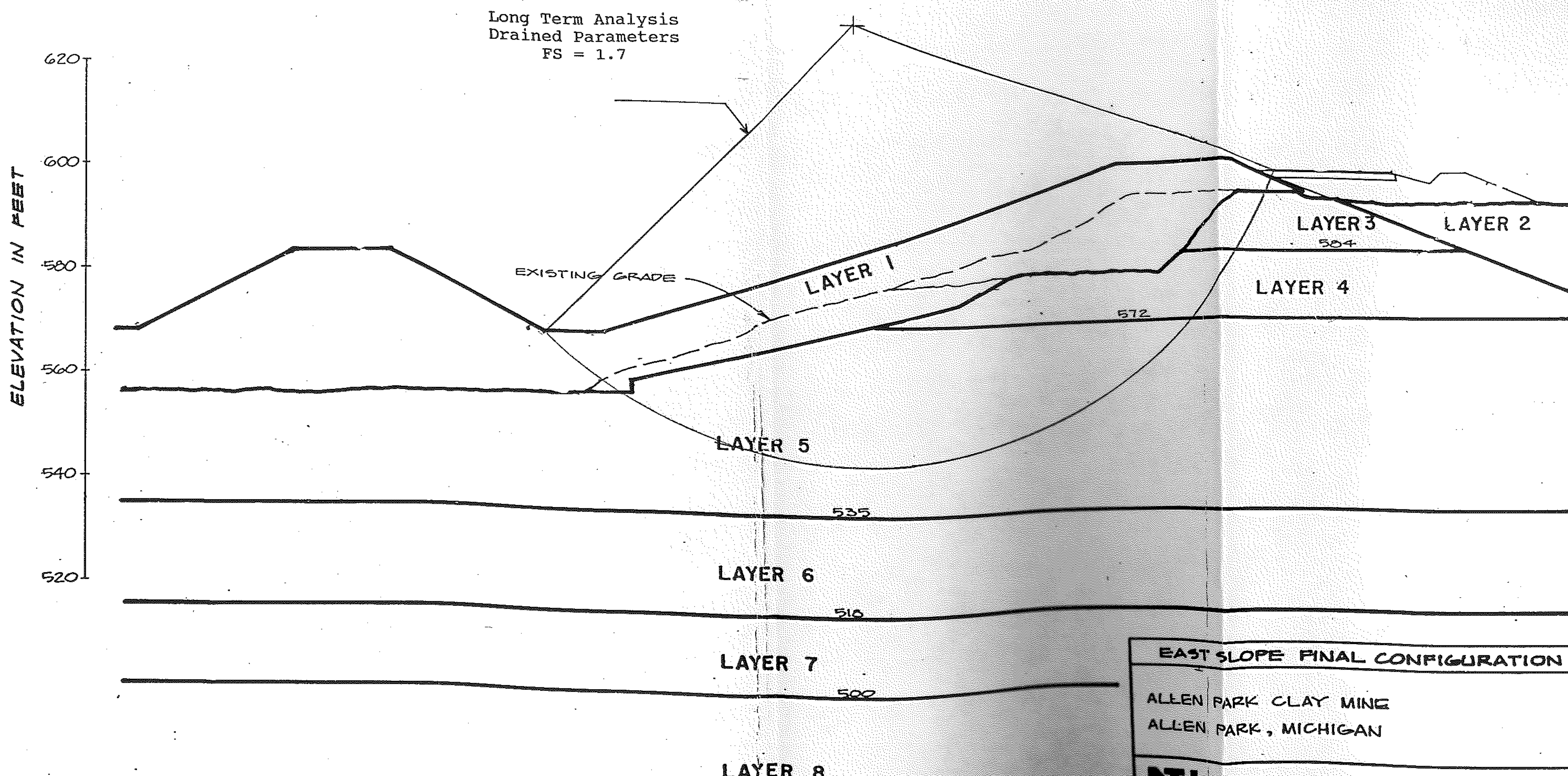
WEST SLOPE FINAL CONFIGURATION

ALLEN PARK CLAY MINE
ALLEN PARK, MICHIGAN

NEYER, TISEO & HINDO, LTD.
CONSULTING ENGINEERS AND GEOLOGISTS
38955 HILLS TECH DRIVE • FARMINGTON HILLS, MI 48018

PROJECT NO.: 88612 AW	DRAWN BY: RK	DATE: 4-11-89
SCALE: 1" = 20'	CHECKED BY: CJG	SHEET 1 OF 1

PLATE 4B



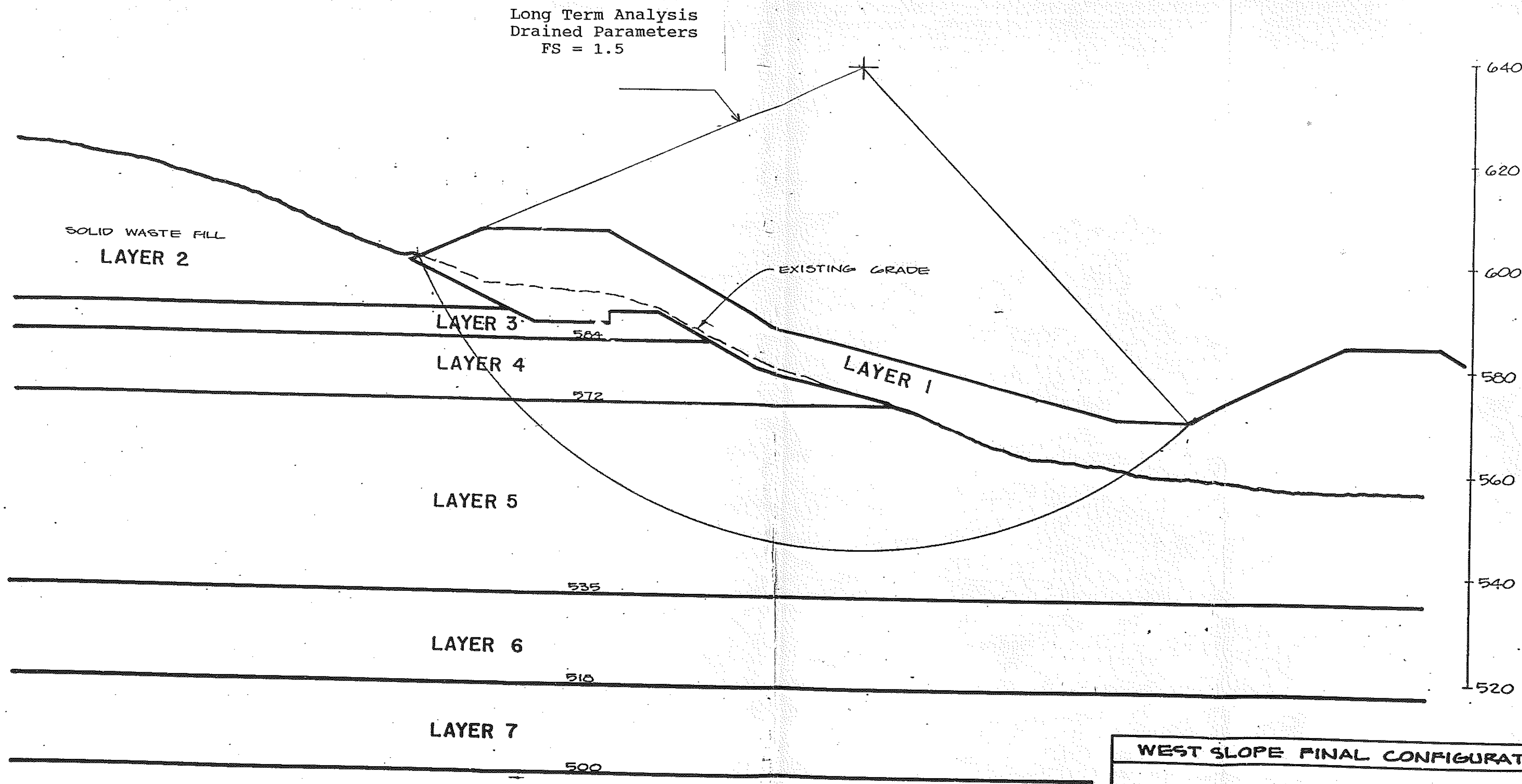
EAST SLOPE FINAL CONFIGURATION

ALLEN PARK CLAY MINE
ALLEN PARK, MICHIGAN

NEYER, TISEO & HINDO, LTD.
CONSULTING ENGINEERS AND GEOLOGISTS
38955 HILLS TECH DRIVE • FARMINGTON HILLS, MI 48018

PROJECT NO.: 88612AW	DRAWN BY: RK	DATE: 4-11-89
SCALE: 1" = 20'	CHECKED BY: CJG	SHEET 1 OF 1

PLATE 5A



WEST SLOPE FINAL CONFIGURATION		
ALLEN PARK CLAY MINE ALLEN PARK, MICHIGAN		
NEYER, TISEO & HINDO, LTD. CONSULTING ENGINEERS AND GEOLOGISTS 38955 HILLS TECH DRIVE • FARMINGTON HILLS, MI 48018		
PROJECT NO.: 8862AW	DRAWN BY: RK	DATE: 4-11-89
SCALE: 1" = 20'	CHECKED BY: CJG	SHEET 1 OF 1

PLATE 5B

NEYER, TISEO & HINDO, LTD.

LOG OF TEST BORING NO. TB-3

Project Name: SUPPLEMENTAL SUBSURFACE INV. / ALLEN PARK CLAY MINE
Project Location: ALLEN PARK, MICHIGAN

NTH Proj. No: 88612 AW
Chk. By: Gh

ELEV. (FT)	SUBSURFACE PROFILE (GROUND SURFACE ELEVATION: 594.7 FT)	DEPTH (FT)	SAMPLE TYPE/NO.	BLOWS/ 6-INCHES	STD. PEN. RESISTANCE (N)	MOISTURE CONTENT (PERCENT)	DRY DENSITY (PCF)	UNCONF. COMP. ST. (PSF)
590	FILL: DARK BROWN SILTY CLAY WITH TRACE OF SAND, GRAVEL AND BRICK FRAGMENTS (to 8.0)	5						
585	STIFF GRAY SILTY CLAY WITH TRACE OF SAND (8.0 to 19.0)	10	S-1	3 3 5	8	–	–	–
580		15	S-2			–	–	–
			PS-1			21.5	110	2180
575	MEDIUM GRAY SILTY CLAY WITH LITTLE TO SOME SAND AND TRACE OF GRAVEL (from 19.0)	20	VS-1			–	–	1106*
570		25	PS-2			17.6	117	–
565		30	VS-2			–	–	1214*
560		35	PS-			–	–	–
			PS-3			18.3	115	1240
555		40	VS-3			–	–	1186*

CONTINUED ON NEXT SHEET

TOTAL DEPTH: 89.5 FT
DRILLING DATE: 1/13-16/89
INSPECTOR: V. PERSON/A. AUGUSTYNIAK
CONTRACTOR: AMERICAN DRILLING CO.
DRILLER: M. MAYRAND

DRILLING METHOD :
4.0 INCHES DIAMETER SOLID STEM AUGER TO 10.0 FEET, 3.8 INCHES DIAMETER ROTARY ROLLER BIT WITH DRILLING FLUID (WATER) RECIRCULATION.

PLUGGING PROCEDURE :
HOLE PLUGGED WITH NON-SHRINKING CEMENT GROUT.

WATER LEVEL OBSERVATION:
NO MEANINGFUL WATER DATA AT COMPLETION SINCE WATER ADDED TO DRILL HOLE.
ARTESIAN CONDITIONS WERE ENCOUNTERED AT END OF BORING.

* AS DETERMINED BY A VANE SHEAR TEST ($2S_u = q_u$)

COORDINATES: N 3986.1 / E 6679.4

FIGURE NO. 1A

NEYER , TISEO & HINDO , LTD.

LOG OF TEST BORING NO. TB-3

Project Name: SUPPLEMENTAL SUBSURFACE INV. / ALLEN PARK CLAY MINE
Project Location: ALLEN PARK, MICHIGAN

NTH Proj. No: 88612 AW
Chk. By: [signature]

SUBSURFACE PROFILE				SOIL SAMPLE DATA					
ELEV. (FT)	PRO-FILE	CONTINUED FROM PREVIOUS SHEET	DEPTH (FT)	SAMPLE TYPE/NO.	BLOWS/ 6-INCHES	STD. PEN. RESISTANCE (N)	MOISTURE CONTENT (PERCENT)	DRY DENSITY (PCF)	UNCONF. COMP. ST. (PSF)
550		MEDIUM GRAY **SILTY CLAY** WITH LITTLE TO SOME SAND AND TRACE OF GRAVEL	45	PS-4			19.4	112	1560
545			50	VS-4			–	–	1692*
540			55	PS-5			19.6	112	1420
535			60	VS-5			–	–	1810*
		62.0							
530		MEDIUM GRAY **SILTY CLAY** WITH LITTLE TO SOME SAND AND TRACE OF GRAVEL	65	PS-6			22.7	105	1420
525			70	VS-6			–	–	1848*
520			75	PS-7			24.3	109	–
		77.0							
515		STIFF GRAY **SILTY CLAY** WITH TRACE TO LITTLE SAND	80	VS-7			–	–	1241*
		80.0							

CONTINUED ON NEXT SHEET

TOTAL DEPTH: 89.5 FT
DRILLING DATE: 1/13-16/89
INSPECTOR: V. PERSON/A. AUGUSTYNIAK
CONTRACTOR: AMERICAN DRILLING CO.
DRILLER: M. MAYRAND

DRILLING METHOD :
4.0 INCHES DIAMETER SOLID STEM AUGER TO 10.0 FEET,
3.8 INCHES DIAMETER ROTARY ROLLER BIT WITH DRILLING FLUID (WATER) RECIRCULATION.

PLUGGING PROCEDURE :
HOLE PLUGGED WITH NON-SHRINKING CEMENT GROUT.

WATER LEVEL OBSERVATION:
NO MEANINGFUL WATER DATA AT COMPLETION SINCE WATER ADDED TO DRILL HOLE.
ARTESIAN CONDITIONS WERE ENCOUNTERED AT END OF BORING.

* AS DETERMINED BY A VANE SHEAR TEST ($2S_u = q_u$)

COORDINATES: N 3986.1 / E 6679.4

FIGURE NO. 1B

NEYER, TISEO & HINDO, LTD.

LOG OF TEST BORING NO. TB-3

Project Name: SUPPLEMENTAL SUBSURFACE INV. / ALLEN PARK CLAY MINE
Project Location: ALLEN PARK, MICHIGAN

NTH Proj. No: 88612 AW
Chk. By: [signature]

SUBSURFACE PROFILE				SOIL SAMPLE DATA					
ELEV. (FT)	PRO-FILE	CONTINUED FROM PREVIOUS SHEET	DEPTH (FT)	SAMPLE TYPE/NO.	BLOWS/ 6-INCHES	STD. PEN. RESISTANCE (N)	MOISTURE CONTENT (PERCENT)	DRY DENSITY (PCF)	UNCONF. COMP. ST. (PSF)
510		STIFF GRAY **SILTY CLAY** WITH TRACE TO LITTLE SAND	85	PS-8			–	–	–
		86.0							
505		HARD GRAY **CLAYEY SILT** WITH SOME SAND [HARDPAN]		S-3	19 25 30	55	–	–	–
		89.5 END OF BORING	90						
500			95						
495			100						
490			105						
485			110						
480			115						
475			120						

TOTAL DEPTH: 89.5 FT
DRILLING DATE: 1/13–16/89
INSPECTOR: V. PERSON/A. AUGUSTYNIAK
CONTRACTOR: AMERICAN DRILLING CO.
DRILLER: M. MAYRAND

DRILLING METHOD:
4.0 INCHES DIAMETER SOLID STEM AUGER TO 10.0 FEET,
3.8 INCHES DIAMETER ROTARY ROLLER BIT WITH DRILLING FLUID (WATER) RECIRCULATION.

PLUGGING PROCEDURE:
HOLE PLUGGED WITH NON–SHRINKING CEMENT GROUT.

WATER LEVEL OBSERVATION:
NO MEANINGFUL WATER DATA AT COMPLETION SINCE WATER ADDED TO DRILL HOLE.
ARTESIAN CONDITIONS WERE ENCOUNTERED AT END OF BORING.

* AS DETERMINED BY A VANE SHEAR TEST ($2S_u = q_u$)

COORDINATES: N 3986.1 / E 6679.4

FIGURE NO. 1C

NEYER, TISEO & HINDO, LTD.

LOG OF TEST BORING NO. TB-4

Project Name: SUPPLEMENTAL SUBSURFACE INV. / ALLEN PARK CLAY MINE
Project Location: ALLEN PARK, MICHIGAN

NTH Proj. No: 88612 AW
Chk. By: [signature]

SUBSURFACE PROFILE

GROUND SURFACE ELEVATION: 594.0 FT

Depth (FT)	Description
0.0 – 9.5	**FILL:** DARK BROWN **SILTY CLAY** WITH PIECES OF BRICK
9.5 – 9.7	LOOSE TAN **SAND**
9.7 – 22.0	STIFF GRAY **SILTY CLAY** WITH TRACE OF SAND AND GRAVEL
22.0 –	MEDIUM GRAY **SILTY CLAY** WITH LITTLE SAND AND TRACE OF GRAVEL

Elevations (FT): 590, 585, 580, 575, 570, 565, 560, 555

CONTINUED ON NEXT SHEET

SOIL SAMPLE DATA

DEPTH (FT)	SAMPLE TYPE/NO.	BLOWS/ 6-INCHES	STD. PEN. RESISTANCE (N)	MOISTURE CONTENT (PERCENT)	DRY DENSITY (PCF)	UNCONF. COMP. ST. (PSF)
10	S-1	5 4 4	8	–	–	–
15	S-2	4 4 7	11	33.2	88	2060
20	PS-1			30.0	95	2230
25	VS-1			–	–	1538*
30	PS-2			19.5	113	1350
35	VS-2			–	–	1332*
40	PS-3			19.2	112	1440

TOTAL DEPTH: 90.0 FT
DRILLING DATE: 1/17-19/89
INSPECTOR: A. AUGUSTYNIAK
CONTRACTOR: AMERICAN DRILLING CO.
DRILLER: M. MAYRAND

DRILLING METHOD :
4.0 INCHES DIAMETER SOLID STEM AUGER TO 10.0 FEET, 3.8 INCHES DIAMETER ROTARY ROLLER BIT WITH DRILLING FLUID (WATER) RECIRCULATION.

PLUGGING PROCEDURE :
HOLE PLUGGED WITH NON-SHRINKING CEMENT GROUT.

WATER LEVEL OBSERVATION:
NO MEANINGFUL WATER DATA AT COMPLETION SINCE WATER ADDED TO DRILL HOLE.

* AS DETERMINED BY A VANE SHEAR TEST ($2S_u = q_u$)

COORDINATES: N 4025.7 / E 7156.8

FIGURE NO. 2A

NEYER , TISEO & HINDO , LTD.

LOG OF TEST BORING NO. TB-4

Project Name: SUPPLEMENTAL SUBSURFACE INV. / ALLEN PARK CLAY MINE
Project Location: ALLEN PARK, MICHIGAN

NTH Proj. No: 88612 AW
Chk. By: gl

SUBSURFACE PROFILE			SOIL SAMPLE DATA					
ELEV. (FT)	CONTINUED FROM PREVIOUS SHEET	DEPTH (FT)	SAMPLE TYPE/NO.	BLOWS/ 6-INCHES	STD. PEN. RESISTANCE (N)	MOISTURE CONTENT (PERCENT)	DRY DENSITY (PCF)	UNCONF. COMP. ST. (PSF)
550	MEDIUM GRAY **SILTY CLAY** WITH LITTLE SAND AND TRACE OF GRAVEL	45	VS-3			–	–	1500*
545		50	PS-4			21.0	115	1140
540		55	VS-4			–	–	1174*
	57.0							
535	MEDIUM GRAY **SILTY CLAY** WITH LITTLE SAND AND TRACE OF GRAVEL	60	PS-5			22.2	107	–
530		65	VS-5			–	–	436*
525		70	PS-6			24.1	105	–
	72.0							
520	STIFF GRAY **SILTY CLAY** WITH TRACE OF SAND AND GRAVEL	75	VS-6			–	–	1118*
515		80	S-3	9 13 15	28	–	–	–

CONTINUED ON NEXT SHEET

TOTAL DEPTH: 90.0 FT
DRILLING DATE: 1/17-19/89
INSPECTOR: A. AUGUSTYNIAK
CONTRACTOR: AMERICAN DRILLING CO.
DRILLER: M. MAYRAND

DRILLING METHOD :
4.0 INCHES DIAMETER SOLID STEM AUGER TO 10.0 FEET, 3.8 INCHES DIAMETER ROTARY ROLLER BIT WITH DRILLING FLUID (WATER) RECIRCULATION.

PLUGGING PROCEDURE :
HOLE PLUGGED WITH NON-SHRINKING CEMENT GROUT.

WATER LEVEL OBSERVATION:
NO MEANINGFUL WATER DATA AT COMPLETION SINCE WATER ADDED TO DRILL HOLE.

* AS DETERMINED BY A VANE SHEAR TEST ($2S_u = q_u$)

COORDINATES: N 4025.7 / E 7156.8

FIGURE NO. 2 B

NEYER , TISEO & HINDO , LTD.

LOG OF TEST BORING NO. TB-4

Project Name: SUPPLEMENTAL SUBSURFACE INV. / ALLEN PARK CLAY MINE
Project Location: ALLEN PARK, MICHIGAN

NTH Proj. No: 88612 AW
Chk. By:

SUBSURFACE PROFILE — CONTINUED FROM PREVIOUS SHEET

ELEV. (FT)	DESCRIPTION	DEPTH (FT)	SAMPLE TYPE/NO.	BLOWS/ 6-INCHES	STD. PEN. RESISTANCE (N)	MOISTURE CONTENT (PERCENT)	DRY DENSITY (PCF)	UNCONF. COMP. ST. (PSF)
510	STIFF GRAY **SILTY CLAY** WITH TRACE OF SAND AND GRAVEL	85	S-4	3 5 6	11	–	–	–
505	(89.0)	90	S-5	9 13 24	37	–	–	–
	HARD GRAY **SILTY CLAY** WITH TRACE OF GRAVEL (90.0)							
	END OF BORING							

Elevation scale: 510, 505, 500, 495, 490, 485, 480, 475
Depth scale: 85, 90, 95, 100, 105, 110, 115, 120

TOTAL DEPTH: 90.0 FT
DRILLING DATE: 1/17-19/89
INSPECTOR: A. AUGUSTYNIAK
CONTRACTOR: AMERICAN DRILLING CO.
DRILLER: M. MAYRAND

DRILLING METHOD :
4.0 INCHES DIAMETER SOLID STEM AUGER TO 10.0 FEET, 3.8 INCHES DIAMETER ROTARY ROLLER BIT WITH DRILLING FLUID (WATER) RECIRCULATION.

PLUGGING PROCEDURE :
HOLE PLUGGED WITH NON-SHRINKING CEMENT GROUT.

WATER LEVEL OBSERVATION:
NO MEANINGFUL WATER DATA AT COMPLETION SINCE WATER ADDED TO DRILL HOLE.

* AS DETERMINED BY A VANE SHEAR TEST ($2S_u = q_u$)

COORDINATES: N 4025.7 / E 7156.8

FIGURE NO. 2C

NEYER, TISEO & HINDO, LTD.

LOG OF TEST BORING NO. TB-5

Project Name: SUPPLEMENTAL SUBSURFACE INV. / ALLEN PARK CLAY MINE
Project Location: ALLEN PARK, MICHIGAN

NTH Proj. No: 88612 AW
Chk. By: [signature]

SUBSURFACE PROFILE				SOIL SAMPLE DATA					
ELEV. (FT)	PROFILE	GROUND SURFACE ELEVATION: 563.2 FT	DEPTH (FT)	SAMPLE TYPE/NO.	BLOWS/ 6-INCHES	STD. PEN. RESISTANCE (N)	MOISTURE CONTENT (PERCENT)	DRY DENSITY (PCF)	UNCONF. COMP. ST. (PSF)
560		SOFT TO MEDIUM GRAY **SILTY CLAY** WITH LITTLE TO SOME SAND AND TRACE OF GRAVEL	5	PS-			-	-	-
				PS-			-	-	-
555			10	PS-1			20.9	109	-
550			15	VS-1			-	-	416*
545			20	PS-2			21.0	111	-
540			25	VS-2			-	-	682*
535			30	PS-3			22.1	104	-
530			35	VS-3			-	-	372*
525			40	PS-4			21.6	109	-

CONTINUED ON NEXT SHEET

TOTAL DEPTH: 58.3 FT
DRILLING DATE: 1/19-20/89
INSPECTOR: A. AUGUSTYNIAK
CONTRACTOR: AMERICAN DRILLING CO.
DRILLER: M. MAYRAND

DRILLING METHOD :
4.0 INCHES DIAMETER SOLID STEM AUGER TO 10.0 FEET, 3.8 INCHES DIAMETER ROTARY ROLLER BIT WITH DRILLING FLUID (WATER) RECIRCULATION.

PLUGGING PROCEDURE :
HOLE PRESSURE-PLUGGED WITH NON-SHRINKING CEMENT GROUT.

WATER LEVEL OBSERVATION:
NO MEANINGFUL WATER DATA AT COMPLETION SINCE WATER ADDED TO DRILL HOLE.
ARTESIAN CONDITIONS WERE ENCOUNTERED AT END OF BORING.

* AS DETERMINED BY A VANE SHEAR TEST ($2S_u = q_u$)

COORDINATES: N 3820.8 / E 6850.3

FIGURE NO. 3A

NEYER, TISEO & HINDO, LTD.

LOG OF TEST BORING NO. TB-5

Project Name: SUPPLEMENTAL SUBSURFACE INV. / ALLEN PARK CLAY MINE
Project Location: ALLEN PARK, MICHIGAN

NTH Proj. No: 88612 AW
Chk. By: [illegible]

ELEV. (FT)	SUBSURFACE PROFILE — CONTINUED FROM PREVIOUS SHEET	DEPTH (FT)	SAMPLE TYPE/NO.	BLOWS/ 6-INCHES	STD. PEN. RESISTANCE (N)	MOISTURE CONTENT (PERCENT)	DRY DENSITY (PCF)	UNCONF. COMP. ST. (PSF)
520	SOFT TO MEDIUM GRAY **SILTY CLAY** WITH LITTLE TO SOME SAND AND TRACE OF GRAVEL (to 43.0)							
	STIFF GRAY **SILTY CLAY** WITH LITTLE SAND AND TRACE OF GRAVEL (43.0 to 56.9)	45	VS-4			–	–	930*
515		50	PS-5			24.7	100	–
510		55	S-1	3 3 5	8	–	–	–
505	HARD GRAY **SILTY CLAY** [HARDPAN] (56.9 to 58.3)		S-2			37.2	85	–
	END OF BORING (58.3)	60						
500		65						
495		70						
490		75						
485		80						

TOTAL DEPTH: 58.3 FT
DRILLING DATE: 1/19-20/89
INSPECTOR: A. AUGUSTYNIAK
CONTRACTOR: AMERICAN DRILLING CO.
DRILLER: M. MAYRAND

DRILLING METHOD :
4.0 INCHES DIAMETER SOLID STEM AUGER TO 10.0 FEET, 3.8 INCHES DIAMETER ROTARY ROLLER BIT WITH DRILLING FLUID (WATER) RECIRCULATION.

PLUGGING PROCEDURE :
HOLE PRESSURE-PLUGGED WITH NON-SHRINKING CEMENT GROUT.

WATER LEVEL OBSERVATION:
NO MEANINGFUL WATER DATA AT COMPLETION SINCE WATER ADDED TO DRILL HOLE.
ARTESIAN CONDITIONS WERE ENCOUNTERED AT END OF BORING.

* AS DETERMINED BY A VANE SHEAR TEST ($2S_u = q_u$)

COORDINATES: N 3820.8 / E 6850.3

FIGURE NO. 3B

NEYER, TISEO & HINDO, LTD.

PROJECT NO.: 88612 OW PROJECT NAME: Allen Park Clay Mine

LOCATION: Allen Park, Michigan DATE: 1/13/89

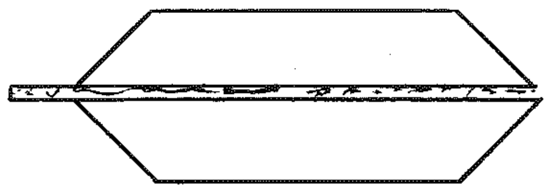
FIELD VANE SHEAR TEST REPORT

TEST NO.	VS-1	ELEV. TOP OF HOLE	594.7
BORING HOLE NO.	TB-3	DEPTH TO TEST POINT	20.0'
LINK & STA.	--	ELEV. OF TEST POINT (Tip of Vane)	574.7
OFFSET	--		

VANE DATA

TORQUE ARM LGTH. 12 IN.

VANE LGTH. 3.5 IN.
VANE DIA. 2.0 IN.



ULTIMATE SHEAR STRENGTH (S) (lbs. / sq. ft.) = 5.17 x APPLIED TORQUE (T) (in. — lbs.) (in. — lbs.)

FRICTION ON VANE SHAFT		UNDISTURBED CONDITION		REMOLDED CONDITION	
Rotation degrees	Force Gage Reading (lbs.)	Rotation degrees	Force Gage Reading (lbs.)	Rotation degrees	Force Gage Reading (lbs.)
--	--	20	8.5	50	3.2
--	--	25	8.5	55	4.0
--	--	30	8.0	60	4.0
--	--	35	8.0	65	4.0

READINGS & CALCULATIONS	UNDISTURBED CONDITION	REMOLDED CONDITION
MAXIMUM FORCE GAGE READINGS for VANE (lbs.)	8.5	4.0
MAXIMUM FORCE GAGE READINGS for SHAFT (lbs.)	--	--
NET FORCE (lbs.)	102	48
APPLIED TORQUE (T) = NET FORCE x TORQUE ARMS (in.-lbs.)	527	248
ULTIMATE SHEAR STRENGTH (S) = $\frac{1}{Ar}$ T		

SENSIVITY = $\frac{\text{Shear Strength (undisturbed)}}{\text{Shear Strength (remolded)}}$ = 2.1

NATURAL WATER CONTENT ______ % HALF-UNCONFINED COMPREHENSIVE STRENGTH ______ lbs. / sq. ft.

TECHNICIAN A. Augustyniak CHECKED BY C. Griffin

COMMENTS Rod joints might be possibly loose during remolding. No resistance.
Increased shear strength by 5% to 553 psf on Bjerrum's Correction Factor.

FIGURE NO. 4

NEYER, TISEO & HINDO, LTD.

PROJECT NO.: 88612 OW PROJECT NAME: Allen Park Clay Mine
LOCATION: Allen Park, Michigan DATE: 1/13/89

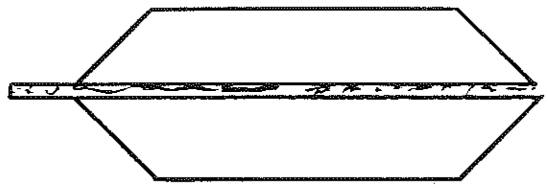
FIELD VANE SHEAR TEST REPORT

TEST NO.	VS-2	ELEV. TOP OF HOLE	594.7
BORING HOLE NO.	TB-3	DEPTH TO TEST POINT	30.0'
LINK & STA.	--	ELEV. OF TEST POINT	564.7
OFFSET	--	(Tip of Vane)	

VANE DATA

TORQUE ARM LGTH. 12 IN.

VANE LGTH. 3.5 IN.
VANE DIA. 2.0 IN.



ULTIMATE SHEAR STRENGTH (S) = 5.17 x APPLIED TORQUE (T) (in.— lbs.)
(lbs. / sq. ft.) (in. — lbs.)

FRICTION ON VANE SHAFT		UNDISTURBED CONDITION		REMOLDED CONDITION	
Rotation degrees	Force Gage Reading (lbs.)	Rotation degrees	Force Gage Reading (lbs.)	Rotation degrees	Force Gage Reading (lbs.)
--	--	70	8.9	10	4.9
--	--	75	8.9	10	4.9
--	--	80	8.9	10	4.9
--	--	85	8.9	10	4.9

READINGS & CALCULATIONS	UNDISTURBED CONDITION	REMOLDED CONDITION
MAXIMUM FORCE GAGE READINGS for VANE (lbs.)	8.9	4.9
MAXIMUM FORCE GAGE READINGS for SHAFT (lbs.)	--	--
NET FORCE (lbs.)	8.9	4.9
APPLIED TORQUE (T) = NET FORCE x TORQUE ARMS (in.-lbs.)	106.8	58.8
ULTIMATE SHEAR STRENGTH (S) = $\frac{1}{Ar}$ T	552	304

SENSIVITY = $\frac{\text{Shear Strength (undisturbed)}}{\text{Shear Strength (remolded)}}$ = 1.8

NATURAL WATER CONTENT ______ % HALF-UNCONFINED COMPREHENSIVE STRENGTH ______ lbs. / sq. ft.

TECHNICIAN A. Augustyniak CHECKED BY C. Griffin

COMMENTS Increased by 10% to 607 psf based on Bjerrum's Correction Factor.

FIGURE NO. 5

NEYER, TISEO & HINDO, LTD.

PROJECT NO.: 88612 OW PROJECT NAME: Allen Park Clay Mine
LOCATION: Allen Park, Michigan DATE: 1/14/89

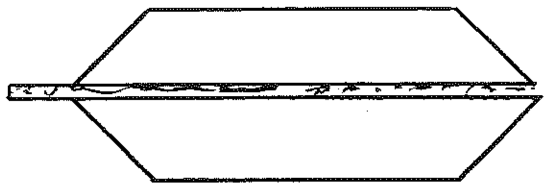
FIELD VANE SHEAR TEST REPORT

TEST NO.	VS-3	ELEV. TOP OF HOLE	594.7
BORING HOLE NO.	TB-3	DEPTH TO TEST POINT	40.0'
LINK & STA.	--	ELEV. OF TEST POINT	554.7
OFFSET	--	(Tip of Vane)	

VANE DATA

TORQUE ARM LGTH. 12 IN.

VANE LGTH. 3.5 IN.
VANE DIA. 2.0 IN.



ULTIMATE SHEAR STRENGTH (S) = 5.17 x APPLIED TORQUE (T) (in.— lbs.)
(lbs. / sq. ft.) (in. — lbs.)

FRICTION ON VANE SHAFT		UNDISTURBED CONDITION		REMOLDED CONDITION	
Rotation degrees	Force Gage Reading (lbs.)	Rotation degrees	Force Gage Reading (lbs.)	Rotation degrees	Force Gage Reading (lbs.)
--	--	30	9.0	30	5.5
--	--	35	9.1	35	6.0
--	--	40	9.1	40	6.0
--	--	45	9.1	45	5.9

READINGS & CALCULATIONS	UNDISTURBED CONDITION	REMOLDED CONDITION
MAXIMUM FORCE GAGE READINGS for VANE (lbs.)	9.1	6.0
MAXIMUM FORCE GAGE READINGS for SHAFT (lbs.)	--	--
NET FORCE (lbs.)	9.1	6.0
APPLIED TORQUE (T) = NET FORCE x TORQUE ARMS (in.-lbs.)	109.2	72
ULTIMATE SHEAR STRENGTH (S) = $\frac{1}{Ar}$ T	565	374

SENSIVITY = $\frac{\text{Shear Strength (undisturbed)}}{\text{Shear Strength (remolded)}}$ = 1.51

NATURAL WATER CONTENT ______ % HALF-UNCONFINED COMPREHENSIVE STRENGTH ______ lbs. / sq. ft.

TECHNICIAN A. Augustyniak CHECKED BY C. Griffin

COMMENTS Increase shear strength by 5% to 593 psf based on Bjerrum's Correction Factor.

FIGURE NO. 6

NEYER, TISEO & HINDO, LTD.

PROJECT NO.: 88612 OW PROJECT NAME: Allen Park Clay Mine
LOCATION: Allen Park, Michigan DATE: 1/14/89

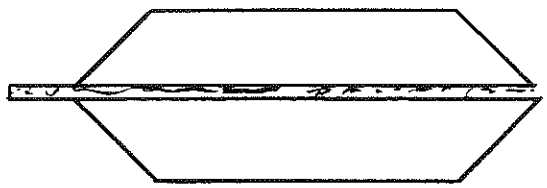
FIELD VANE SHEAR TEST REPORT

TEST NO.	VS-4	ELEV. TOP OF HOLE	594.7
BORING HOLE NO.	TB-3	DEPTH TO TEST POINT	50.0'
LINK & STA.	--	ELEV. OF TEST POINT	544.7
OFFSET	--	(Tip of Vane)	

VANE DATA

TORQUE ARM LGTH. 12 IN.

VANE LGTH. 3.5 IN.
VANE DIA. 2.0 IN.



ULTIMATE SHEAR STRENGTH (S) = 5.17 x APPLIED TORQUE (T) (in. — lbs.)
(lbs. / sq. ft.) (in. — lbs.)

FRICTION ON VANE SHAFT		UNDISTURBED CONDITION		REMOLDED CONDITION	
Rotation degrees	Force Gage Reading (lbs.)	Rotation degrees	Force Gage Reading (lbs.)	Rotation degrees	Force Gage Reading (lbs.)
--	--	85	12.9	45	7.8
--	--	90	12.9	50	8.0
--	--	95	13.0	55	8.0
--	--	100	13.0	60	7.9

READINGS & CALCULATIONS	UNDISTURBED CONDITION	REMOLDED CONDITION
MAXIMUM FORCE GAGE READINGS for VANE (lbs.)	13.0	8.0
MAXIMUM FORCE GAGE READINGS for SHAFT (lbs.)	--	--
NET FORCE (lbs.)	13.0	8.0
APPLIED TORQUE (T) = NET FORCE x TORQUE ARMS (in.-lbs.)	156	96
ULTIMATE SHEAR STRENGTH (S) = $\frac{1}{Ar}$ T	806	496

SENSIVITY = $\frac{\text{Shear Strength (undisturbed)}}{\text{Shear Strength (remolded)}}$ = 1.6

NATURAL WATER CONTENT ______ % HALF-UNCONFINED COMPREHENSIVE STRENGTH ______ lbs. / sq. ft.

TECHNICIAN A. Augustyniak CHECKED BY C. Griffin

COMMENTS Increased by 5% to 846 psf based on Bjerrum's Correction Factor.

FIGURE NO. 7

NEYER, TISEO & HINDO, LTD.

PROJECT NO.: 88612 OW PROJECT NAME: Allen Park Clay Mine

LOCATION: Allen Park, Michigan DATE: 1/16/89

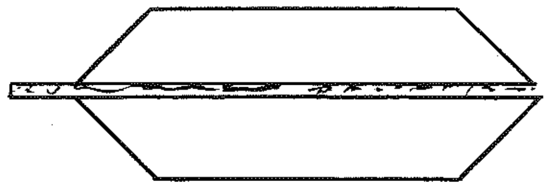
FIELD VANE SHEAR TEST REPORT

TEST NO.	VS-5	ELEV. TOP OF HOLE	594.7
BORING HOLE NO.	TB-3	DEPTH TO TEST POINT	60.0'
LINK & STA.	--	ELEV. OF TEST POINT	534.7
OFFSET	--	(Tip of Vane)	

VANE DATA

TORQUE ARM LGTH. 12 IN.

VANE LGTH. 3.5 IN.
VANE DIA. 2.0 IN.



ULTIMATE SHEAR STRENGTH (S) (lbs. / sq. ft.) = 5.17 x APPLIED TORQUE (T) (in. — lbs.) (in. — lbs.)

FRICTION ON VANE SHAFT		UNDISTURBED CONDITION		REMOLDED CONDITION	
Rotation degrees	Force Gage Reading (lbs.)	Rotation degrees	Force Gage Reading (lbs.)	Rotation degrees	Force Gage Reading (lbs.)
--	--	55	13.7	40	7.7
--	--	60	13.9	45	9.0
--	--	65	13.9	50	9.0
--	--	70	13.9	55	9.0

READINGS & CALCULATIONS	UNDISTURBED CONDITION	REMOLDED CONDITION
MAXIMUM FORCE GAGE READINGS for VANE (lbs.)	13.9	9.0
MAXIMUM FORCE GAGE READINGS for SHAFT (lbs.)	--	--
NET FORCE (lbs.)	13.9	9.0
APPLIED TORQUE (T) = NET FORCE x TORQUE ARMS (in.-lbs.)	166.8	108
ULTIMATE SHEAR STRENGTH $(S) = \frac{1}{Ar} T$	862	558

SENSIVITY = $\frac{\text{Shear Strength (undisturbed)}}{\text{Shear Strength (remolded)}}$ = 1.5

NATURAL WATER CONTENT ______ % HALF-UNCONFINED COMPREHENSIVE STRENGTH ______ lbs. / sq. ft.

TECHNICIAN A. Augustyniak CHECKED BY C. Griffin

COMMENTS Increased by 5% to 905 psf based on Bjerrum's Correction Factor.

FIGURE NO. 8

NEYER, TISEO & HINDO, LTD.

PROJECT NO.: 88612 OW PROJECT NAME: Allen Park Clay Mine
LOCATION: Allen Park, Michigan DATE: 1/16/89

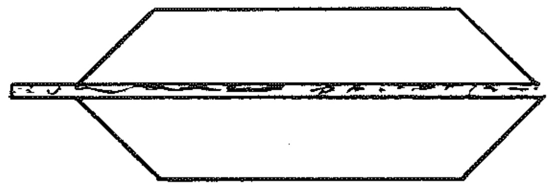
FIELD VANE SHEAR TEST REPORT

TEST NO.	VS-6	ELEV. TOP OF HOLE	594.7
BORING HOLE NO.	TB-3	DEPTH TO TEST POINT	70.0'
LINK & STA.	--	ELEV. OF TEST POINT	524.7
OFFSET	--	(Tip of Vane)	

VANE DATA

TORQUE ARM LGTH. 12 IN.

VANE LGTH. 3.5 IN.
VANE DIA. 2.0 IN.



ULTIMATE SHEAR STRENGTH (S) = 5.17 x APPLIED TORQUE (T) (in. — lbs.)
(lbs. / sq. ft.) (in. — lbs.)

FRICTION ON VANE SHAFT		UNDISTURBED CONDITION		REMOLDED CONDITION	
Rotation degrees	Force Gage Reading (lbs.)	Rotation degrees	Force Gage Reading (lbs.)	Rotation degrees	Force Gage Reading (lbs.)
--	--	40	14.5	30	7.3
--	--	45	14.9	35	8.1
--	--	50	14.9	40	7.9
--	--	55	14.8	45	7.8

READINGS & CALCULATIONS	UNDISTURBED CONDITION	REMOLDED CONDITION
MAXIMUM FORCE GAGE READINGS for VANE (lbs.)	14.9	8.1
MAXIMUM FORCE GAGE READINGS for SHAFT (lbs.)	--	--
NET FORCE (lbs.)	14.9	8.1
APPLIED TORQUE (T) = NET FORCE x TORQUE ARMS (in.-lbs.)	178.8	97.2
ULTIMATE SHEAR STRENGTH (S) = $\frac{1}{Ar}$ T	924	503

SENSIVITY = $\frac{\text{Shear Strength (undisturbed)}}{\text{Shear Strength (remolded)}}$ = 1.84

NATURAL WATER CONTENT ______ % HALF-UNCONFINED COMPREHENSIVE STRENGTH ______ lbs. / sq. ft.

TECHNICIAN A. Augustyniak CHECKED BY C. Griffin

COMMENTS No increase needed per Bjerrum's Correction Factor.

FIGURE NO. 9

NEYER, TISEO & HINDO, LTD.

PROJECT NO.: 88612 OW PROJECT NAME: Allen Park Clay Mine
LOCATION: Allen Park, Michigan DATE: 1/16/89

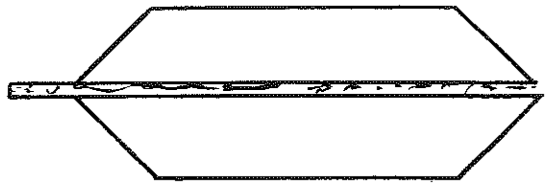
FIELD VANE SHEAR TEST REPORT

TEST NO.	VS-7	ELEV. TOP OF HOLE	594.7
BORING HOLE NO.	TB-3	DEPTH TO TEST POINT	80.0'
LINK & STA.	--	ELEV. OF TEST POINT	514.7
OFFSET	--	(Tip of Vane)	

VANE DATA

TORQUE ARM LGTH. 12 IN.

VANE LGTH. 3.5 IN.
VANE DIA. 2.0 IN.



ULTIMATE SHEAR STRENGTH (S) (lbs. / sq. ft.) = 5.17 x APPLIED TORQUE (T) (in. — lbs.) (in. — lbs.)

FRICTION ON VANE SHAFT		UNDISTURBED CONDITION		REMOLDED CONDITION	
Rotation degrees	Force Gage Reading (lbs.)	Rotation degrees	Force Gage Reading (lbs.)	Rotation degrees	Force Gage Reading (lbs.)
--	--	25	19.2	45	11.0
--	--	30	20.0	50	11.0
--	--	35	19.2	55	11.2
--	--	40	19.2	60	11.2

READINGS & CALCULATIONS	UNDISTURBED CONDITION	REMOLDED CONDITION
MAXIMUM FORCE GAGE READINGS for VANE (lbs.)	20.0	11.2
MAXIMUM FORCE GAGE READINGS for SHAFT (lbs.)	--	--
NET FORCE (lbs.)	20.0	11.2
APPLIED TORQUE (T) = NET FORCE x TORQUE ARMS (in.- lbs.)	240.0	134.4
ULTIMATE SHEAR STRENGTH $(S) = \frac{1}{Ar} T$	1241	695

SENSIVITY = $\frac{\text{Shear Strength (undisturbed)}}{\text{Shear Strength (remolded)}}$ = 1.8

NATURAL WATER CONTENT ______ % HALF-UNCONFINED COMPREHENSIVE STRENGTH ______ lbs. / sq. ft.

TECHNICIAN A. Augustyniak CHECKED BY C. Griffin

COMMENTS No increase needed per Bjerrum's Correction Factor.

FIGURE NO. 10

NEYER, TISEO & HINDO, LTD.

PROJECT NO.: 88612 OW PROJECT NAME: Allen Park Clay Mine

LOCATION: Allen Park, MIchigan DATE: 1/17/89

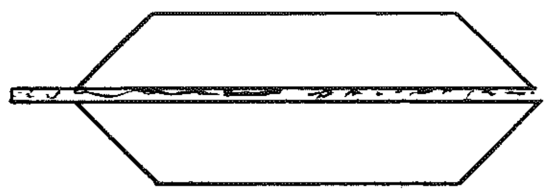
FIELD VANE SHEAR TEST REPORT

TEST NO.	VS-1	ELEV. TOP OF HOLE	594.0
BORING HOLE NO.	TB-4	DEPTH TO TEST POINT	25.0'
LINK & STA.	--	ELEV. OF TEST POINT	569.0
OFFSET	--	(Tip of Vane)	

VANE DATA

TORQUE ARM LGTH. 12 IN.

VANE LGTH. 4.5 IN.
VANE DIA. 2.5 IN.



ULTIMATE SHEAR STRENGTH (S) = 2.59 x APPLIED TORQUE (T) (in.— lbs.)
(lbs. / sq. ft.) (in. — lbs.)

FRICTION ON VANE SHAFT		UNDISTURBED CONDITION		REMOLDED CONDITION	
Rotation degrees	Force Gage Reading (lbs.)	Rotation degrees	Force Gage Reading (lbs.)	Rotation degrees	Force Gage Reading (lbs.)
--	--	15	22.5	5	8.0
--	--	20	22.0	10	8.0
--	--	25	21.2	15	8.0
--	--	30	19.2	20	8.0

READINGS & CALCULATIONS	UNDISTURBED CONDITION	REMOLDED CONDITION
MAXIMUM FORCE GAGE READINGS for VANE (lbs.)	22.5	8.0
MAXIMUM FORCE GAGE READINGS for SHAFT (lbs.)	--	--
NET FORCE (lbs.)	22.5	8.0
APPLIED TORQUE (T) = NET FORCE x TORQUE ARMS (in.-lbs.)	270	96.0
ULTIMATE SHEAR STRENGTH (S) = $\frac{1}{Ar}$ T	699	249

SENSIVITY = $\frac{\text{Shear Strength (undisturbed)}}{\text{Shear Strength (remolded)}}$ = 2.8

NATURAL WATER CONTENT ______ % HALF-UNCONFINED COMPREHENSIVE STRENGTH ______ lbs. / sq. ft.

TECHNICIAN A. Augustyniak CHECKED BY C. Griffin

COMMENTS Increased by 10% to 769 psf based on Bjerrum Correction Factor.

FIGURE NO. 11

NEYER, TISEO & HINDO, LTD.

PROJECT NO.: 88612 OW PROJECT NAME: Allen Park Clay Mine
LOCATION: Allen Park, Michigan DATE: 1/17/89

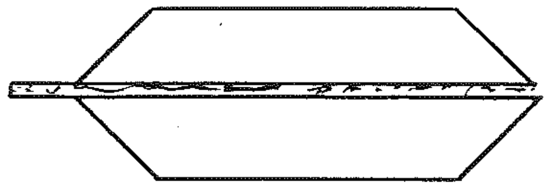
FIELD VANE SHEAR TEST REPORT

TEST NO.	VS-2	ELEV. TOP OF HOLE	594.0
BORING HOLE NO.	TB-4	DEPTH TO TEST POINT	35.0'
LINK & STA.	--	ELEV. OF TEST POINT	559.0
OFFSET	--	(Tip of Vane)	

VANE DATA

TORQUE ARM LGTH. 12 IN.

VANE LGTH. 4.5 IN.
VANE DIA. 2.5 IN.



ULTIMATE SHEAR STRENGTH (S) (lbs. / sq. ft.) = 2.59 x APPLIED TORQUE (T) (in. — lbs.) (in. — lbs.)

FRICTION ON VANE SHAFT		UNDISTURBED CONDITION		REMOLDED CONDITION	
Rotation degrees	Force Gage Reading (lbs.)	Rotation degrees	Force Gage Reading (lbs.)	Rotation degrees	Force Gage Reading (lbs.)
--	--	10	18	15	10
--	--	15	20	20	10
--	--	20	20	25	10
--	--	25	20	30	10

READINGS & CALCULATIONS	UNDISTURBED CONDITION	REMOLDED CONDITION
MAXIMUM FORCE GAGE READINGS for VANE (lbs.)	20	10
MAXIMUM FORCE GAGE READINGS for SHAFT (lbs.)	--	--
NET FORCE (lbs.)	20	10
APPLIED TORQUE (T) = NET FORCE x TORQUE ARMS (in.-lbs.)	240	120
ULTIMATE SHEAR STRENGTH (S) = $\frac{1}{Ar}$ T	622	311

SENSIVITY = $\frac{\text{Shear Strength (undisturbed)}}{\text{Shear Strength (remolded)}}$ = 2.0

NATURAL WATER CONTENT ______ %
HALF-UNCONFINED COMPREHENSIVE STRENGTH ______ lbs. / sq. ft.

TECHNICIAN A. Augustyniak CHECKED BY C. Griffin

COMMENTS Increased by 7% to 666 psf based on Bjerrum's Correction Factor.

FIGURE NO. 12

NEYER, TISEO & HINDO, LTD.

PROJECT NO.: 88612 OW   PROJECT NAME: Allen Park Clay Mine
LOCATION: Allen Park, Michigan   DATE: 1/17/89

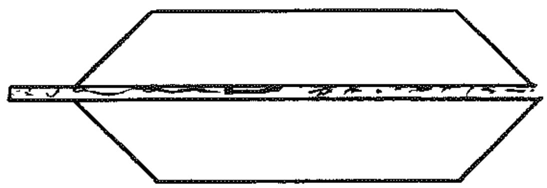
FIELD VANE SHEAR TEST REPORT

TEST NO.	VS-3	ELEV. TOP OF HOLE	594.0
BORING HOLE NO.	TB-4	DEPTH TO TEST POINT	45.0'
LINK & STA.	--	ELEV. OF TEST POINT	549.0
OFFSET	--	(Tip of Vane)	

VANE DATA

TORQUE ARM LGTH. 12 IN.

VANE LGTH. 4.5 IN.
VANE DIA. 2.5 IN.



ULTIMATE SHEAR STRENGTH (S) (lbs./sq. ft.) = 2.59 x APPLIED TORQUE (T) (in. — lbs.) (in. — lbs.)

FRICTION ON VANE SHAFT		UNDISTURBED CONDITION		REMOLDED CONDITION	
Rotation degrees	Force Gage Reading (lbs.)	Rotation degrees	Force Gage Reading (lbs.)	Rotation degrees	Force Gage Reading (lbs.)
--	--	20	23	20	8.9
--	--	25	22.5	25	9.0
--	--	30	21.8	30	9.0
--	--	35	21.8	35	9.0

READINGS & CALCULATIONS	UNDISTURBED CONDITION	REMOLDED CONDITION
MAXIMUM FORCE GAGE READINGS for VANE (lbs.)	23.0	9.0
MAXIMUM FORCE GAGE READINGS for SHAFT (lbs.)	--	--
NET FORCE (lbs.)	23.0	9.0
APPLIED TORQUE (T) = NET FORCE x TORQUE ARMS (in.-lbs.)	276	108
ULTIMATE SHEAR STRENGTH (S) = $\frac{1}{Ar}$ T	715	280

SENSIVITY = $\frac{\text{Shear Strength (undisturbed)}}{\text{Shear Strength (remolded)}}$ = 2.6

NATURAL WATER CONTENT ______ %   HALF-UNCONFINED COMPREHENSIVE STRENGTH ______ lbs./sq. ft.

TECHNICIAN A. Augustyniak   CHECKED BY C. Griffin

COMMENTS Increased by 5% to 750 psf based on Bjerrum's Correction Factor.

FIGURE NO. 13

NEYER, TISEO & HINDO, LTD.

PROJECT NO.: 88612 OW PROJECT NAME: Allen Park Clay Mine
LOCATION: Allen Park, Michigan DATE: 1/18/89

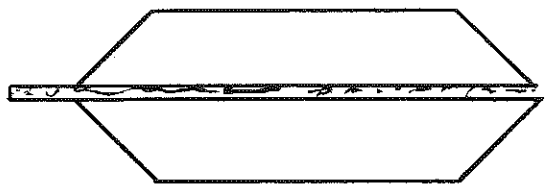
FIELD VANE SHEAR TEST REPORT

TEST NO.	VS-4	ELEV. TOP OF HOLE	594.0
BORING HOLE NO.	TB-4	DEPTH TO TEST POINT	55.0
LINK & STA.	--	ELEV. OF TEST POINT	539.0
OFFSET	--	(Tip of Vane)	

VANE DATA

TORQUE ARM LGTH. 12 IN.

VANE LGTH. 4.5 IN.
VANE DIA. 2.5 IN.



ULTIMATE SHEAR STRENGTH (S) = 2.59 x APPLIED TORQUE (T) (in. — lbs.)
(lbs. / sq. ft.) (in. — lbs.)

FRICTION ON VANE SHAFT		UNDISTURBED CONDITION		REMOLDED CONDITION	
Rotation degrees	Force Gage Reading (lbs.)	Rotation degrees	Force Gage Reading (lbs.)	Rotation degrees	Force Gage Reading (lbs.)
--	--	10	14.1	10	6.2
--	--	15	18.0	15	6.5
--	--	20	18.0	20	6.2
--	--	25	17.0	25	6.0

READINGS & CALCULATIONS	UNDISTURBED CONDITION	REMOLDED CONDITION
MAXIMUM FORCE GAGE READINGS for VANE (lbs.)	18.0	6.5
MAXIMUM FORCE GAGE READINGS for SHAFT (lbs.)	--	--
NET FORCE (lbs.)	18.0	6.5
APPLIED TORQUE (T) = NET FORCE x TORQUE ARMS (in.-lbs.)	216.0	78.0
ULTIMATE SHEAR STRENGTH $(S) = \frac{1}{Ar} T$	559	202

$$\text{SENSIVITY} = \frac{\text{Shear Strength (undisturbed)}}{\text{Shear Strength (remolded)}} = 2.8$$

NATURAL WATER CONTENT ____ % HALF-UNCONFINED COMPREHENSIVE STRENGTH ____ lbs. / sq. ft.

TECHNICIAN A. Augustyniak CHECKED BY C. Griffin

COMMENTS Increased by 5% to 587 psf based on Bjerrum's Correction Factor.

FIGURE NO. 14

NEYER, TISEO & HINDO, LTD.

PROJECT NO.: 88612 OW **PROJECT NAME:** Allen Park Clay Mine
LOCATION: Allen Park, Michigan **DATE:** 1/18/89

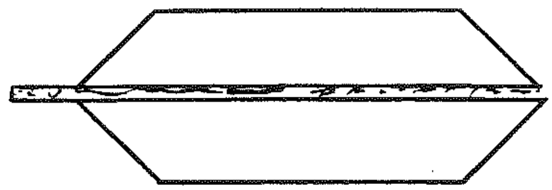
FIELD VANE SHEAR TEST REPORT

TEST NO.	VS-5	ELEV. TOP OF HOLE	594.0
BORING HOLE NO.	TB-4	DEPTH TO TEST POINT	65.0'
LINK & STA.	--	ELEV. OF TEST POINT	529.0
OFFSET	--	(Tip of Vane)	

VANE DATA

TORQUE ARM LGTH. 12 IN.

VANE LGTH. 4.5 IN.
VANE DIA. 2.5 IN.



ULTIMATE SHEAR STRENGTH (S) (lbs./sq. ft.) = 2.59 x APPLIED TORQUE (T) (in. — lbs.) (in. — lbs.)

FRICTION ON VANE SHAFT		UNDISTURBED CONDITION		REMOLDED CONDITION	
Rotation degrees	Force Gage Reading (lbs.)	Rotation degrees	Force Gage Reading (lbs.)	Rotation degrees	Force Gage Reading (lbs.)
--	--	5	5	10	7.0
--	--	10	7.0	15	7.5
--	--	15	7.0	20	7.0
--	--	20	7.0	25	7.0

READINGS & CALCULATIONS	UNDISTURBED CONDITION	REMOLDED CONDITION
MAXIMUM FORCE GAGE READINGS for VANE (lbs.)	7.0	7.5
MAXIMUM FORCE GAGE READINGS for SHAFT (lbs.)	--	--
NET FORCE (lbs.)	7.0	7.5
APPLIED TORQUE (T) = NET FORCE x TORQUE ARMS (in.-lbs.)	84	
ULTIMATE SHEAR STRENGTH $(S) = \frac{1}{Ar} T$	218*	233*

SENSIVITY = $\frac{\text{Shear Strength (undisturbed)}}{\text{Shear Strength (remolded)}}$ = 0.93

NATURAL WATER CONTENT ______ % HALF-UNCONFINED COMPREHENSIVE STRENGTH ______ lbs./sq. ft.

TECHNICIAN A. Augustyniak CHECKED BY C. Griffin

COMMENTS * Casing may have slipped during test.

FIGURE NO. 15

NEYER, TISEO & HINDO, LTD.

PROJECT NO.: 88612 OW PROJECT NAME: Allen Park Clay MIne

LOCATION: Allen Park, Michigan DATE: 1/18/89

FIELD VANE SHEAR TEST REPORT

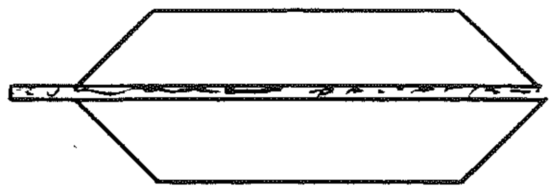
TEST NO.	VS-6	ELEV. TOP OF HOLE	594.0
BORING HOLE NO.	TB-4	DEPTH TO TEST POINT	75.0'
LINK & STA.	--	ELEV. OF TEST POINT	519.0
OFFSET	--	(Tip of Vane)	

VANE DATA

TORQUE ARM LGTH. 12 IN.

VANE LGTH. 4.5 IN.

VANE DIA. 2.5 IN.



ULTIMATE SHEAR STRENGTH (S) = 2.59 x APPLIED TORQUE (T) (in. — lbs.)
(lbs. / sq. ft.) (in. — lbs.)

FRICTION ON VANE SHAFT		UNDISTURBED CONDITION		REMOLDED CONDITION	
Rotation degrees	Force Gage Reading (lbs.)	Rotation degrees	Force Gage Reading (lbs.)	Rotation degrees	Force Gage Reading (lbs.)
--	--	10	15	15	19.0
--	--	15	17.5	20	19.5
--	--	20	18	25	19.0
				30	18.5

READINGS & CALCULATIONS	UNDISTURBED CONDITION	REMOLDED CONDITION
MAXIMUM FORCE GAGE READINGS for VANE (lbs.)	18	19.5
MAXIMUM FORCE GAGE READINGS for SHAFT (lbs.)	--	--
NET FORCE (lbs.)	18	19.5
APPLIED TORQUE (T) = NET FORCE x TORQUE ARMS (in.-lbs.)	216	234
ULTIMATE SHEAR STRENGTH (S) = $\frac{1}{Ar}$ T	559	606

SENSIVITY = $\frac{\text{Shear Strength (undisturbed)}}{\text{Shear Strength (remolded)}}$ = 0.92

NATURAL WATER CONTENT ______ % HALF-UNCONFINED COMPREHENSIVE STRENGTH ______ lbs. / sq. ft.

TECHNICIAN A. Augustyniak CHECKED BY C. Griffin

COMMENTS During undisturbed test casing started turning. Test ended.
During remolding pipe wrench was secured to prevent casing from moving.

FIGURE NO. 16

NEYER, TISEO & HINDO, LTD.

PROJECT NO.: 88612 OW PROJECT NAME: Allen Park Clay Mine

LOCATION: Allen Park, Michigan DATE: 1/19/89

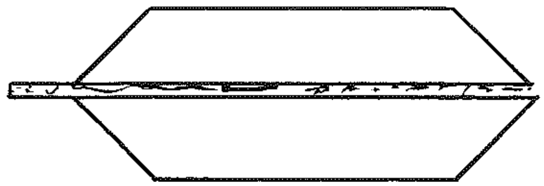
FIELD VANE SHEAR TEST REPORT

TEST NO.	VS-1	ELEV. TOP OF HOLE	563.2
BORING HOLE NO.	TB-5	DEPTH TO TEST POINT	15.0
LINK & STA.	--	ELEV. OF TEST POINT	548.20
OFFSET	--	(Tip of Vane)	

VANE DATA

TORQUE ARM LGTH. 12 IN.

VANE LGTH. 3.5 IN.
VANE DIA. 2.0 IN.



ULTIMATE SHEAR STRENGTH (S) (lbs. / sq. ft.) = 5.17 x APPLIED TORQUE (T) (in. — lbs.) (in. — lbs.)

FRICTION ON VANE SHAFT		UNDISTURBED CONDITION		REMOLDED CONDITION	
Rotation degrees	Force Gage Reading (lbs.)	Rotation degrees	Force Gage Reading (lbs.)	Rotation degrees	Force Gage Reading (lbs.)
--	--	20	3.2	10	1.8
--	--	25	3.2	15	2.0
--	--	30	3.2	20	2.0
--	--	35	3.2	25	2.0

READINGS & CALCULATIONS	UNDISTURBED CONDITION	REMOLDED CONDITION
MAXIMUM FORCE GAGE READINGS for VANE (lbs.)	3.2	2.0
MAXIMUM FORCE GAGE READINGS for SHAFT (lbs.)	--	--
NET FORCE (lbs.)	3.2	2.0
APPLIED TORQUE (T) = NET FORCE x TORQUE ARMS (in.-lbs.)	38.4	24.0
ULTIMATE SHEAR STRENGTH $(S) = \frac{1}{Ar} T$	198	124

$$\text{SENSIVITY} = \frac{\text{Shear Strength (undisturbed)}}{\text{Shear Strength (remolded)}} = 1.6$$

NATURAL WATER CONTENT ______ %

HALF-UNCONFINED COMPREHENSIVE STRENGTH ______ lbs. / sq. ft.

TECHNICIAN A. Augustyniak CHECKED BY C. Griffin

COMMENTS *Low test result indicates dial gauge may have malfunctioned.

FIGURE NO. 17

NEYER, TISEO & HINDO, LTD.

PROJECT NO.: 88612 OW PROJECT NAME: Allen Park Clay Mine

LOCATION: Allen Park, Michigan DATE: 1/19/89

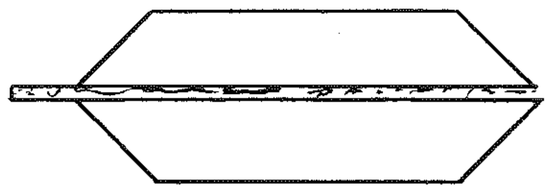
FIELD VANE SHEAR TEST REPORT

TEST NO.	VS-2	ELEV. TOP OF HOLE	563.2
BORING HOLE NO.	TB-5	DEPTH TO TEST POINT	25.0
LINK & STA.	--	ELEV. OF TEST POINT	538.2
OFFSET	--	(Tip of Vane)	

VANE DATA

TORQUE ARM LGTH. 12 IN.

VANE LGTH. 3.5 IN.
VANE DIA. 2.0 IN.



ULTIMATE SHEAR STRENGTH (S) (lbs. / sq. ft.) = 5.17 x APPLIED TORQUE (T) (in. — lbs.) (in. — lbs.)

FRICTION ON VANE SHAFT		UNDISTURBED CONDITION		REMOLDED CONDITION	
Rotation degrees	Force Gage Reading (lbs.)	Rotation degrees	Force Gage Reading (lbs.)	Rotation degrees	Force Gage Reading (lbs.)
--	--	10	5.0	5	1.0
--	--	15	5.5	10	1.0
--	--	20	5.0	15	1.0
--	--	25	5.0	20	1.0

READINGS & CALCULATIONS	UNDISTURBED CONDITION	REMOLDED CONDITION
MAXIMUM FORCE GAGE READINGS for VANE (lbs.)	5.5	1.0
MAXIMUM FORCE GAGE READINGS for SHAFT (lbs.)	--	--
NET FORCE (lbs.)	5.5	1.0
APPLIED TORQUE (T) = NET FORCE x TORQUE ARMS (in.-lbs.)	66.0	12.0
ULTIMATE SHEAR STRENGTH (S) = $\frac{1}{Ar}$ T	341 *	62.1

SENSIVITY = $\frac{\text{Shear Strength (undisturbed)}}{\text{Shear Strength (remolded)}}$ = 5.5

NATURAL WATER CONTENT ______ % HALF-UNCONFINED COMPREHENSIVE STRENGTH ______ lbs. / sq. ft.

TECHNICIAN A. Augustyniak CHECKED BY C. Griffin

COMMENTS *Low test result indicates dial gauge may have malfunctioned.

NEYER, TISEO & HINDO, LTD.

PROJECT NO.: 88612 OW PROJECT NAME: Allen Park Clay Mine
LOCATION: Allen Park, Michigan DATE: 1/20/89

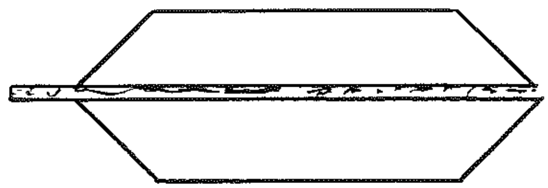
FIELD VANE SHEAR TEST REPORT

TEST NO.	VS-3	ELEV. TOP OF HOLE	563.2
BORING HOLE NO.	TB-5	DEPTH TO TEST POINT	35.0
LINK & STA.	--	ELEV. OF TEST POINT	528.2
OFFSET	--	(Tip of Vane)	

VANE DATA

TORQUE ARM LGTH. 12 IN.

VANE LGTH. 3.5 IN.
VANE DIA. 2.0 IN.



ULTIMATE SHEAR STRENGTH (S) (lbs. / sq. ft.) = 5.17 x APPLIED TORQUE (T) (in. — lbs.)

FRICTION ON VANE SHAFT		UNDISTURBED CONDITION		REMOLDED CONDITION	
Rotation degrees	Force Gage Reading (lbs.)	Rotation degrees	Force Gage Reading (lbs.)	Rotation degrees	Force Gage Reading (lbs.)
--	--	20	3.0	35	3.0
--	--	25	3.0	40	3.0
--	--	30	3.0	45	3.0
--	--	35	3.0	50	3.0

READINGS & CALCULATIONS	UNDISTURBED CONDITION	REMOLDED CONDITION
MAXIMUM FORCE GAGE READINGS for VANE (lbs.)	3.0	3.0
MAXIMUM FORCE GAGE READINGS for SHAFT (lbs.)	--	--
NET FORCE (lbs.)	3.0	3.0
APPLIED TORQUE (T) = NET FORCE x TORQUE ARMS (in.-lbs.)	36	36
ULTIMATE SHEAR STRENGTH (S) = $\frac{1}{Ar}$ T	186 *	186

SENSIVITY = $\frac{\text{Shear Strength (undisturbed)}}{\text{Shear Strength (remolded)}}$ = 1.0

NATURAL WATER CONTENT ______ % HALF-UNCONFINED COMPREHENSIVE STRENGTH ______ lbs. / sq. ft.

TECHNICIAN A. Augustyniak CHECKED BY C. Griffin

COMMENTS *Low test result indicates dial gauge may have malfunctioned.

FIGURE NO. 19

NEYER, TISEO & HINDO, LTD.

PROJECT NO.: 88612 OW PROJECT NAME: Allen Park Clay Mine

LOCATION: Allen Park, Michigan DATE: 1/20/89

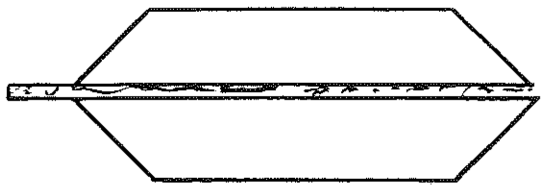
FIELD VANE SHEAR TEST REPORT

TEST NO.	VS-4	ELEV. TOP OF HOLE	563.2
BORING HOLE NO.	TB-5	DEPTH TO TEST POINT	45.0'
LINK & STA.	--	ELEV. OF TEST POINT (Tip of Vane)	518.20
OFFSET	--		

VANE DATA

TORQUE ARM LGTH. 12 IN.

VANE LGTH. 3.5 IN.
VANE DIA. 2.0 IN.



ULTIMATE SHEAR STRENGTH (S) (lbs. / sq. ft.) = 5.17 x APPLIED TORQUE (T) (in. — lbs.) (in. — lbs.)

FRICTION ON VANE SHAFT		UNDISTURBED CONDITION		REMOLDED CONDITION	
Rotation degrees	Force Gage Reading (lbs.)	Rotation degrees	Force Gage Reading (lbs.)	Rotation degrees	Force Gage Reading (lbs.)
--	--	20	7.0	10	2.0
--	--	25	7.5	20	2.0
--	--	30	7.5	25	2.0
--	--	35	7.0	30	2.0

READINGS & CALCULATIONS	UNDISTURBED CONDITION	REMOLDED CONDITION
MAXIMUM FORCE GAGE READINGS for VANE (lbs.)	7.5	2.0
MAXIMUM FORCE GAGE READINGS for SHAFT (lbs.)	--	--
NET FORCE (lbs.)	7.5	2.0
APPLIED TORQUE (T) = NET FORCE x TORQUE ARMS (in.-lbs.)	90	24
ULTIMATE SHEAR STRENGTH (S) = $\frac{1}{Ar}$ T	465	124

SENSIVITY = $\frac{\text{Shear Strength (undisturbed)}}{\text{Shear Strength (remolded)}}$ = 3.7

NATURAL WATER CONTENT ______ %   HALF-UNCONFINED COMPREHENSIVE STRENGTH ______ lbs. / sq. ft.

TECHNICIAN A. Augustyniak CHECKED BY ______

COMMENTS No increase needed per Bjerrum's Correction Factor.

FIGURE NO. 20

PROJECT NO. 88612 AW	NEYER , TISEO & HINDO , LTD.	SHEET 1 OF 2

TABULATION OF TEST DATA

Test Boring or Test Pit Number	Sample Number	Depth of Sample Tip	Elevation of Sample Tip	Unconfined Compressive Strength (PSF)	Failure Strain (Percent)	Natural Water Content (Percent of Dry Weight)	In-Place Dry Density (Pounds per Cubic Foot)	Permeability (Centimeters per Second)	Particle Size Distribution: Colloids (Percent)	Clay (Percent)	Silt (Percent)	Fine Sand (Percent)	Medium Sand (Percent)	Coarse Sand (Percent)	Gravel (Percent)	Atterberg Limits: Liquid Limit (Percent)	Plastic Limit (Percent)	Plasticity Index (Percent)	Apparent Specific Gravity	Unified Soil Classification
TB-3	PS-1T	18.0	576.7	2070	11.2	24.2	103.5	–	–	–	–	–	–	–	–	27	15	12	–	CL
	PS-1	20.0	574.7	2180	14.3	21.5	110.2	–	–	–	–	–	–	–	–				–	–
	PS-2	27.0	567.7	–	–	17.6	116.7	–	–	–	–	–	–	–	–	21	14	7	–	CL
	PS-3T	37.0	557.7	1500	15.0	18.1	116.5	–	–	–	–	–	–	–	–	24	15	9	–	CL
	PS-3	39.0	555.7	1240	15.0	18.3	114.6	–	–	–	–	–	–	–	–				–	–
	PS-4T	45.0	549.7	1690	15.0	19.8	106.8	–	–	–	–	–	–	–	–	28	15	13	–	CL
	PS-4	47.0	547.7	1560	15.0	19.4	111.5	–	–	–	–	–	–	–	–				–	–
	PS-5	55.0	539.7	1420	14.5	19.6	112.3	–	–	–	–	–	–	–	–	30	17	13	–	CL
	PS-6T	65.0	529.7	1420	15.0	23.2	105.5	–	–	–	–	–	–	–	–	31	18	13	–	CL
	PS-6	67.0	527.7	1420	15.0	22.7	104.7	–	–	–	–	–	–	–	–				–	–
	PS-7	75.0	519.7	–	–	24.3	109.3	–	–	–	–	–	–	–	–	34	18	16	–	CL
TB-4	S-2	15.0	579.0	2060	15.0	33.2	88.0	–	–	–	–	–	–	–	–				–	–
	PS-1	20.0	574.0	2230	14.5	30.0	95.3	–	–	–	–	–	–	–	–	38	20	18	–	CL
	PS-2T	30.5	563.5	1710	15.0	18.7	116.0	–	–	–	–	–	–	–	–	23	16	7	–	CL
	PS-2	32.5	561.5	1350	15.0	19.5	112.6	–	–	–	–	–	–	–	–				–	–
	PS-3	40.0	554.0	1440	14.5	19.2	111.9	–	–	–	–	–	–	–	–	26	15	11	–	CL
	PS-4T	50.0	544.0	1430	15.0	20.1	111.0	–	–	–	–	–	–	–	–	29	17	12	–	CL
	PS-4	52.0	542.0	1140	15.0	21.0	114.8	–	–	–	–	–	–	–	–				–	–
	PS-5	62.0	532.0	–	–	22.2	106.9	–	–	–	–	–	–	–	–	31	18	13	–	CL
	PS-6	70.0	524.0	–	–	24.1	104.5	–	–	–	–	–	–	–	–	52	26	26	–	CH

FIGURE 21

PROJECT NO. 88612 OW | NEYER, TISEO & HINDO, LTD. | SHEET 2 OF 2

TABULATION OF TEST DATA

									Particle Size Distribution							Atterberg Limits				
Test Boring or Test Pit Number	Sample Number	Depth of Sample Tip	Elevation of Sample Tip	Unconfined Compressive Strength (PSF)	Failure Strain (Percent)	Natural Water Content (Percent of Dry Weight)	In-Place Dry Density (Pounds per Cubic Foot)	Permeability (Centimeters per Second)	Colloids (Percent)	Clay (Percent)	Silt (Percent)	Fine Sand (Percent)	Medium Sand (Percent)	Coarse Sand (Percent)	Gravel (Percent)	Liquid Limit (Percent)	Plastic Limit (Percent)	Plasticity Index (Percent)	Apparent Specific Gravity	Unified Soil Classification
TB- 5	PS-1	10.5	552.7	810	19.0	20.9	109.1	-	-	-	-	-	-	-	-	30	17	13	-	CL
	PS-2	20.0	543.2	1000	19.3	21.0	111.2	-	-	-	-	-	-	-	-	32	17	15	-	CL
	PS-3	28.5	534.7	-	-	22.1	104.4	-	-	-	-	-	-	-	-	31	18	13	-	CL
	PS-4	40.0	523.2	-	-	21.6	108.7	-	-	-	-	-	-	-	-	34	17	17	-	CL
	PS-5	49.0	514.2	-	-	24.7	100.3	-	-	-	-	-	-	-	-	38	19	19	-	CL
	SS-1	55.0	508.2	920	15.0	37.2	84.8	-	-	-	-	-	-	-	-	53	24	29	-	CH

FIGURE 22

NEYER, TISEO & HINDO, LTD.

CONSOLIDATION TEST

LAB SAMPLE # #12 PROJECT NO. 88612 AW SHEET ___ OF ___

FOR Allen Park Clay Mine DATE 2-10-89

PROJECT LOCATION Allen Park, Michigan TESTED BY SG

BORING # 4 FIELD SAMPLE # PS-3 SAMPLE ELEV. (TIP) 554.0 CHECKED BY CJG

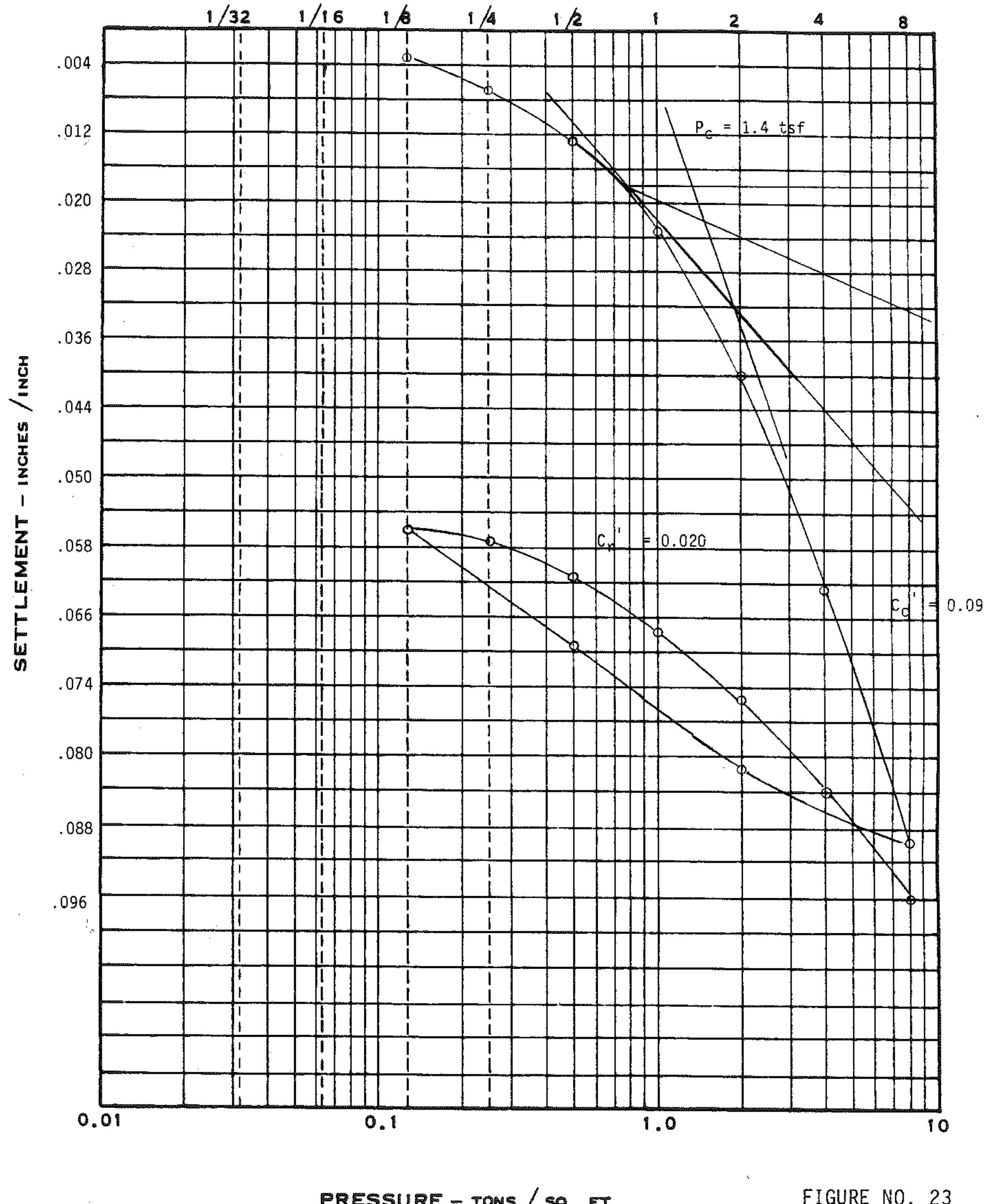


FIGURE NO. 23

NEYER, TISEO & HINDO, LTD.

CONSOLIDATION TEST

LAB SAMPLE # #12 PROJECT NO. 88612 AW SHEET ____ OF ____

FOR Allen Park Clay Mine DATE 2-10-89

PROJECT LOCATION Allen Park, Michigan TESTED BY SG

BORING # 4 FIELD SAMPLE # PS-3 SAMPLE ELEV. (TIP) 554.0 CHECKED BY CJG

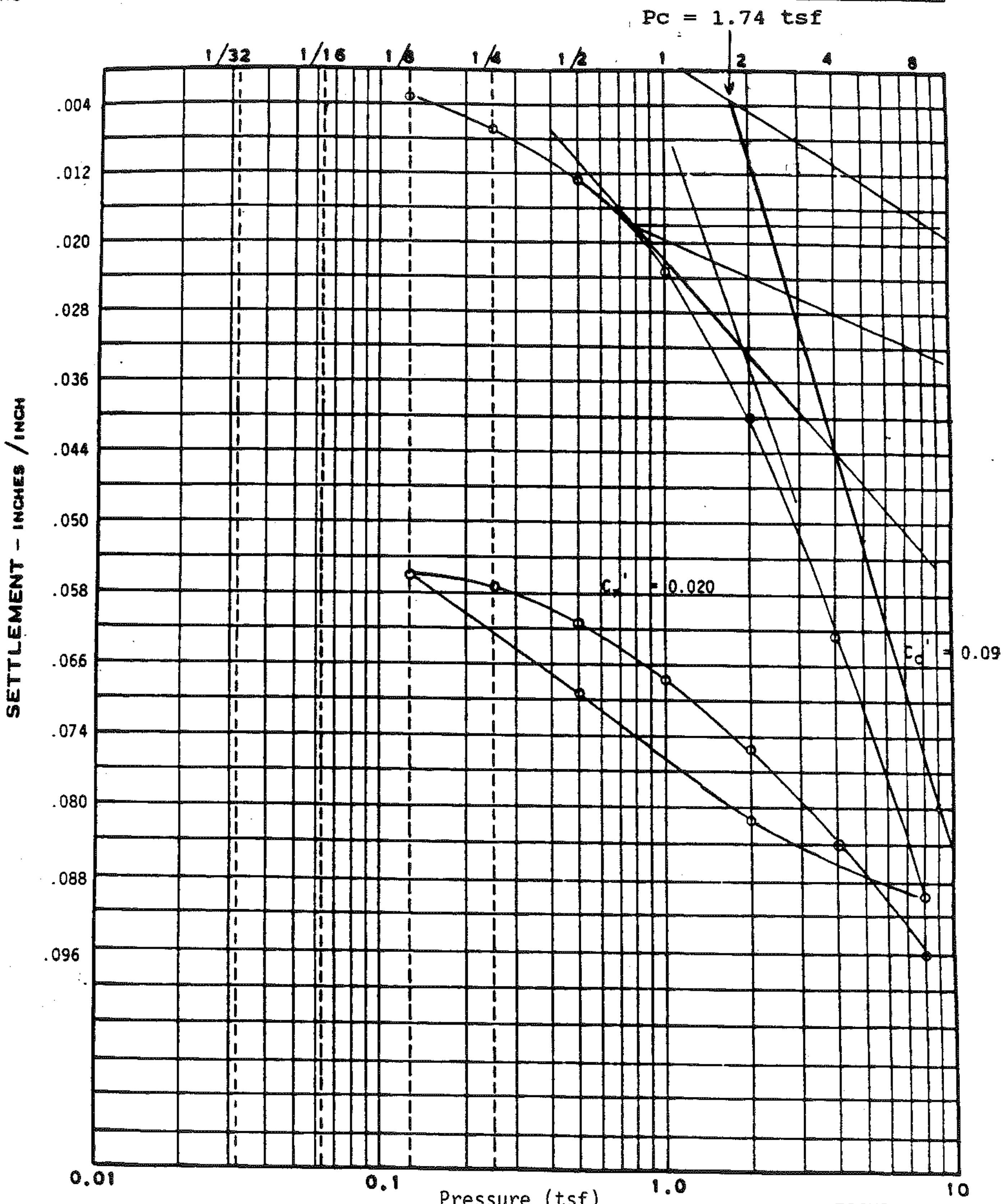


FIGURE 24

NEYER, TISEO & HINDO, LTD.

CONSOLIDATION TEST

LAB SAMPLE # #11	PROJECT NO. 88612 OW	SHEET ___ OF ___	
FOR Allen Park Clay Mine		DATE 2-9-89	
PROJECT LOCATION Allen Park Michigan		TESTED BY SG	
BORING # 3	FIELD SAMPLE # PS 5 SAMPLE ELEV. (TIP) 539.7	CHECKED BY CJG	

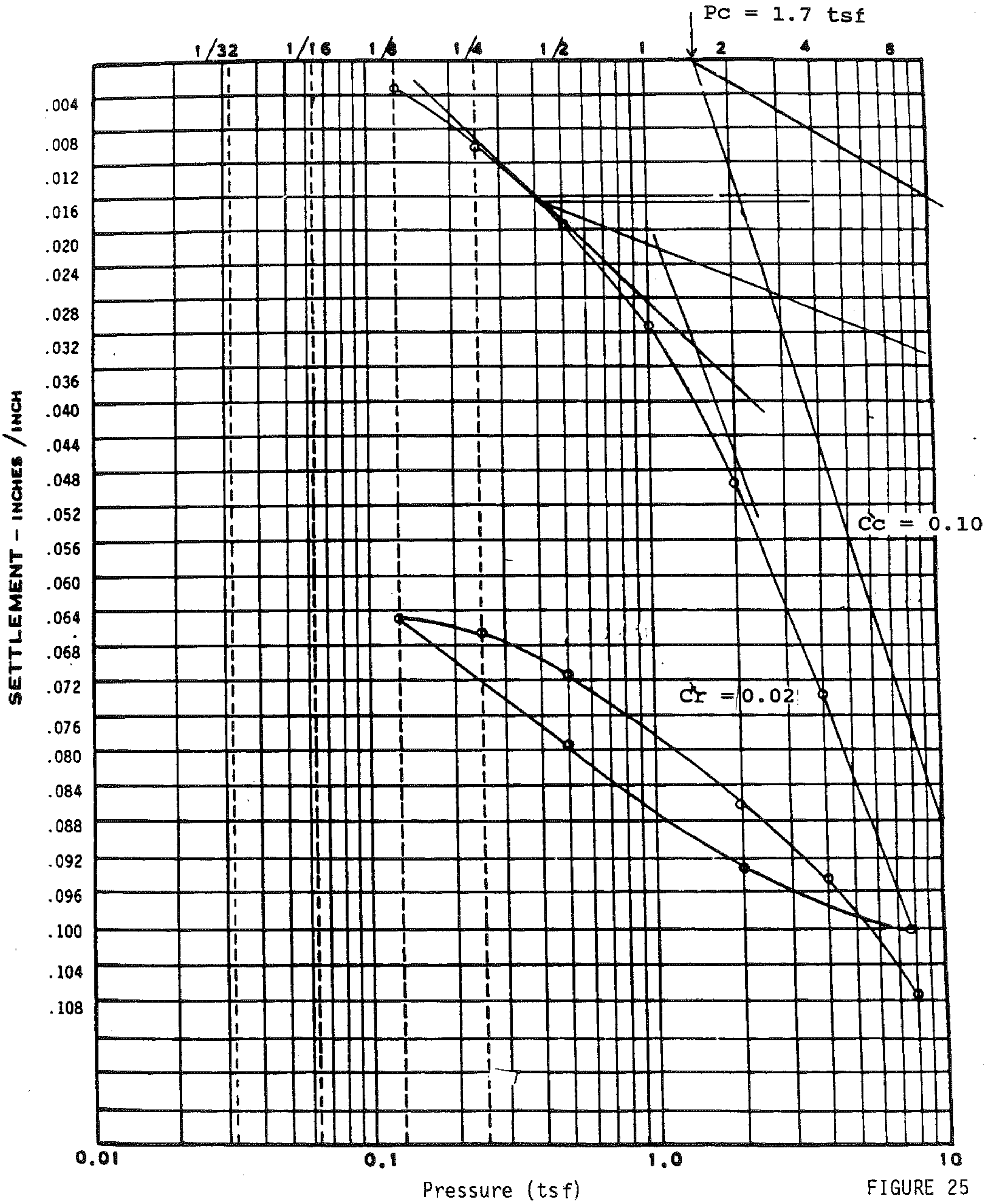
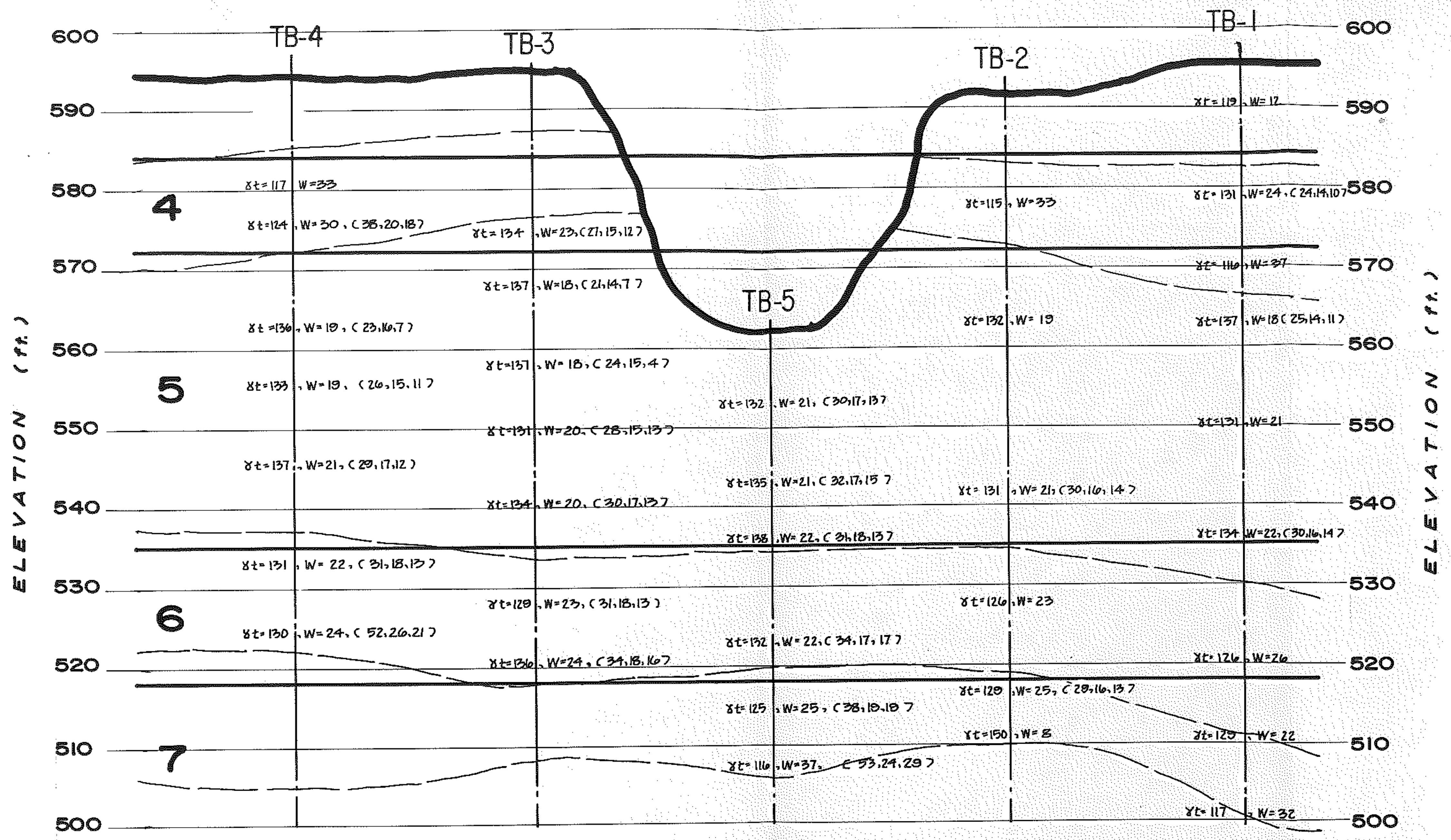


FIGURE 25



NOTE: NO HORIZONTAL SCALE

LEGEND

ESTIMATED ACTUAL SUBSURFACE ELEVATIONS

DESIGN SUBSURFACE PROFILE ELEVATIONS

4 LAYER DESIGNATIONS

SUMMARY OF SOIL INDEX PROPERTIES

ALLEN PARK CLAY MINE LANDFILL
HAZARDOUS CELL II
ALLEN PARK, MICHIGAN

NTH NEYER, TISEO & HINDO, LTD.
CONSULTING ENGINEERS AND GEOLOGISTS
38955 HILLS TECH DRIVE • FARMINGTON HILLS, MI 48018

PROJECT NO.: 88612 AW	DRAWN BY: Guy	DATE: 7-7-89
SCALE: Not to Scale	CHECKED BY: LK	SHEET 1 OF 1

FIGURE 26

LOG OF SUBSURFACE PROFILE

CLASSIFICATIONS BY: NEYER, TISEO & HINDO, LTD.

GROUND SURFACE ELEVATION: 595.6

Elevation (feet)	Description	Depth
590	FILL: Black SILTY SAND AND GRAVEL with Wood, Wire, Brick, Concrete and Black Foundry Sand.	13.6
580–500	Soft to Medium Gray SILTY CLAY with Trace of Sand.	95.0
	Very Compact Gray SAND AND GRAVEL.	100.0

ELEVATION—FEET

SOIL SAMPLE DATA

SAMPLE NUMBER	ELEV. (FEET)	NATURAL MOISTURE CONTENT (PERCENT)	DRY DENSITY (PCF)	PENETRATION RESISTANCE
LS-1	590.6	12.4	101.4	6-5-5
LS-2	585.6	-	-	7-6-6
LS-3	580.6	-	-	2-3-4
PS-1	578.1	21.9	105.9	PUSHED
LS-4	575.6	-	-	1-1-2
LS-5	570.6	36.6	84.7	1-1-1
PS-2	563.1	17.9	116.4	PUSHED
VS-1	560.6	-	-	
LS-6	555.6	-	-	1-2-3
LS-7	550.6	21.1	107.9	1-2-3
LS-8	545.6	-	-	2-2-3
VS-2	540.6	-	-	
PS-3	535.1	21.7	110.3	PUSHED
S-1	530.6	-	-	2-3-4
VS-3	525.6	-	-	
LS-9	520.6	25.9	99.7	3-3-3
LS-10	515.6	-	-	2-3-4
LS-11	510.6	21.7	106.2	5-8-11
LS-12	505.6	-	-	4-5-6
LS-13	500.6	31.6	88.5	8-4-7
LS-14	495.6	NO RECOVERY		19-32-70/5"

NOTES:
1. Borings advanced using 4-inch diameter solid-stem augers to 10 feet, and 3-7/8 inch diameter tricone roller bit with recirculating drilling fluid to bottom of hole. 4-inch diameter casing was driven to 12.5 feet.
2. Artesian water pressure was observed after penetrating the hardpan layer. No piezometric level was ob-
3. 2-inch diameter well installed. See Log of Monitoring Well No. MW-1.

TOTAL DEPTH: 100.0'
BORING STARTED: 12/19/84
BORING COMPLETED: 12/26/84
INSPECTOR: L. Kendall/D. Vensel
DRILLER: J. Blank
CONTRACTOR: American Drilling Co.

▽ WATER LEVEL, IN HOLE AT INDICATED NUMBER OF HOURS AFTER COMPLETION OF BORING WITH 0 FEET OF CASING IN PLACE.

*PENETRATION RESISTANCE: NUMBER OF BLOWS REQUIRED TO DRIVE 2 INCH O.D. SOIL SAMPLER 12 INCHES, USING 140 POUND WEIGHT FALLING 30 ...

NEYER, TISEO & HINDO, LTD.
CONSULTING ENGINEERS

LOG OF TEST BORING NUMBER TB-1

ALLEN PARK CLAY MINE LANDFILL
FORD MOTOR COMPANY
ALLEN PARK, MICHIGAN

APPROVED BY:
DATE: 1/11/85

LOG OF SUBSURFACE PROFILE

CLASSIFICATIONS BY:
NEYER, TISEO & HINDO, LTD.

GROUND SURFACE ELEVATION:
591.9

Elevation (feet)	Depth	Description
590	2.5	FILL: Compact Dark Brown SILTY SAND with Slag.
ENC. (water level)	9.0	FILL: Loose to Medium Compact Gray SILTY FINE SAND with Little Clay.
580–520	76.5	Soft to Medium Gray SILTY CLAY with Trace of Sand.
510	80.0	Very Hard Gray CLAYEY SILT with Some Fine Sand and Gravel. (Hardpan)

ELEVATION—FEET

NOTES:
1. Borings advanced using 6-inch diameter solid-stem augers to 10 feet, and 3-7/8 inch diameter tricone roller bit with recirculating drilling fluid to bottom of hole. 4-inch diameter casing was driven to 12.5 feet.
2. Groundwater was encountered at 8.2 feet during drilling.
3. Boring backfilled with cement grout to surface.

SOIL SAMPLE DATA

SAMPLE NUMBER	ELEV. (FEET)	NATURAL MOISTURE CONTENT (PERCENT)	DRY DENSITY (PCF)	PENETRATION* RESISTANCE 0 10 20 30 40
S-1	586.9	18.9	-	3-3-2
LS-1	581.9	-	-	4-5-7
LS-2	576.9	33.1	86.8	2-2-3
LS-3	571.9	-	-	2-2-4
VS-1	566.9	-	-	
LS-4	561.9	18.6	111.6	2-3-4
LS-5	556.9	-	-	2-3-4
LS-6	551.9	-	-	2-3-3
LS-7	546.9	-	-	2-3-3
PS-1	541.4	21.3	108.4	PUSHED
LS-8	536.9	-	-	2-3-4
VS-2	531.9	-	-	
LS-9	526.9	22.8	102.6	2-3-4
LS-10	521.9	-	-	2-3-4
PS-2	516.4	24.6	103.5	PUSHED
LS-11	511.9	8.3	138.9	18-28-48

TOTAL DEPTH: 80.0'
BORING STARTED: 12/26/84
BORING COMPLETED: 12/27/84
INSPECTOR: D. Vensel
DRILLER: J. Blank
CONTRACTOR: American Drilling Co.

WATER LEVEL IN HOLE AT INDICATED NUMBER OF HOURS AFTER COMPLETION OF BORING WITH 0 FEET OF CASING IN PLACE.

*PENETRATION RESISTANCE: NUMBER OF BLOWS REQUIRED TO DRIVE 2 INCH

NEYER, TISEO & HINDO, LTD.
CONSULTING ENGINEERS

LOG OF TEST BORING NUMBER TB-2

ALLEN PARK CLAY MINE LANDFILL
FORD MOTOR COMPANY
ALLEN PARK, MICHIGAN

ROJECT NO. 84185 OW

NEYER, TISEO & HINDO, LTD.

SHEET 1 OF 2

TABULATION OF TEST DATA

								Volumetric Analysis			Particle Size Distribution							Atterberg Limits				
Test Pit Number	Sample Number	Depth of Sample Tip	Elevation of Sample Tip	Unconfined Compressive Strength (PSF)	Failure Strain (Percent)	Natural Water Content (Percent of Dry Weight)	In-Place Dry Density (Pounds per Cubic Foot)	Solids (Percent)	Liquids (Percent)	Air (Percent)	Colloids (Percent)	Clay (Percent)	Silt (Percent)	Fine Sand (Percent)	Medium Sand (Percent)	Coarse Sand (Percent)	Gravel (Percent)	Liquid Limit (Percent)	Plastic Limit (Percent)	Plasticity Index (Percent)	Apparent Specific Gravity	
1	LS-1	5.0	590.6	-	-	12.4	101.4											-	-	-		
1	PS-1	17.5	578.1	1440	18.0	23.9	105.9											24	14	10		
1	LS-5	25.0	570.6	-	-	36.6	84.7											-	-	-		
1	PS-2	32.5	563.1	1280	20.0	17.9	116.4											25	14	11		
1	LS-7	45.0	550.1	-	-	21.1	107.9											-	-	-		
1	PS-3	60.5	535.1	1160	20.0	21.7	110.3											30	16	14		
1	LS-9	75.0	520.6	-	-	25.9	99.7											-	-	-		
1	LS-11	85.0	510.6	-	-	21.7	106.2											-	-	-		
1	LS-13	95.0	500.6	-	-	31.6	88.5											-	-	-		
2	S-1	5.0	586.9	-	-	18.9	-											-	-	-		
2	LS-2	15.0	576.9	-	-	33.1	86.8											-	-	-		
2	LS-4	30.0	561.9	-	-	18.6	111.6											-	-	-		
2	PS-1	50.5	541.4	1380	20.0	21.3	108.4	(See Consolidation Test Results)										30	16	14		
2	LS-9	65.0	526.9	-	-	22.8	102.6											-	-	-		

ROJECT NO. 84185 OW

NEYER, TISEO & HINDO, LTD.

TABULATION OF TEST DATA

Test Pit Number	Sample Number	Depth of Sample Tip	Elevation of Sample Tip	Unconfined Compressive Strength (PSF)	Failure Strain (Percent)	Natural Water Content (Percent of Dry Weight)	In-Place Dry Density (Pounds per Cubic Foot)	Volumetric Analysis: Solids (Percent)	Volumetric Analysis: Liquids (Percent)	Volumetric Analysis: Air (Percent)	Particle Size Distribution: Colloids (Percent)	Particle Size Distribution: Clay (Percent)	Particle Size Distribution: Silt (Percent)	Particle Size Distribution: Fine Sand (Percent)	Particle Size Distribution: Medium Sand (Percent)	Particle Size Distribution: Coarse Sand (Percent)	Particle Size Distribution: Gravel (Percent)	Atterberg Limits: Liquid Limit (Percent)	Atterberg Limits: Plastic Limit (Percent)	Atterberg Limits: Plasticity Index (Percent)	Apparent Specific Gravity
2	PS-2	75.5	516.4	910	10.0	24.6	103.5											29	16	13	
2	LS-11	80.0	511.9	-	-	8.3	138.9											-	-	-	

Project No. 34135 NEYER, TISEO & HINDO, LTD.

Project Allen Park Clay Mine Landfill

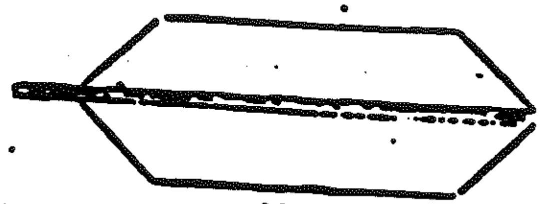
Location Allen Park, Michigan **DATE** December 19, 1984

FIELD VANE SHEAR TEST REPORT

TEST NO.	VS-1	ELEV. TOP OF HOLE	595.6
BORING HOLE NO.	TB-1	DEPTH TO TEST POINT	35.0
LINE & STA.	-	ELEV. OF TEST POINT (Tip of Vane)	560.6
OFFSET	-		

VANE DATA

TORQUE ARM LGTH. 12 IN.
TORQUE ARM DIA. 3/4 IN.
VANE LGTH. 5 IN.
VANE DIA. 2½ IN.



Ultimate Shear Strength (S) (Lbs./Sq. Ft.) = $\frac{30.87}{12}$ x Applied Torque (T) (In. - Lbs.)

FRICTION ON VANE SHAFT		UNDISTURBED CONDITION		REMOLDED CONDITION	
Rotation (Degrees)	Force Gage Reading (Lbs)	Rotation (Degrees)	Force Gage Reading (Lbs)	Rotation (Degrees)	Force Gage Reading (Lbs)
		5	23	5	14.0
		10	28.5	10	15.5
		12	29	15	15.5
		15	28	20	15.5
		20	27.5		
		25	28.5	25	15.5
		30	29		
		35	27		

READINGS & CALCULATIONS	UNDISTURBED CONDITION	REMOLDED CONDITION
Maximum Force Gage Reading for Vane (Lbs)	29.0	15.5
Maximum Force Gage Reading for Shaft (Lbs)	-	-
Net Force (Lbs)	29.0	15.5
Applied Torque (T) = Net Force x Torque Arm (In-Lbs)	348.0	186.0
Ultimate Shear Strength (S) = $\frac{1}{AF}$ T	895	478

Sensivity = $\frac{\text{Shear Strength (Undisturbed)}}{\text{Shear Strength (Remolded)}}$ = 1.87

Natural Water Content 17.9 % (Sample PS-2) Half-Unconfined Comprehensive Strength 640 Lbs./Sq. Ft.

TECHNICIAN LK CHECKED BLF

Comments Increase shear strength by 7% to 960 psf based on Bjerrum's connection factor (Ref.1).

Ref 1: Bjerrum, L. "Embankments on Soft Ground", Proceedings of the Specialty Conference on Performance of Earth and Earth Supported Structures, ASCE Vol. 2, 1972, pp 1-54

Project No. 54155

NEYER, TISEO & HINDO, LTD.

Project Allen Park Clay Mine Landfill

Location Allen Park, Michigan

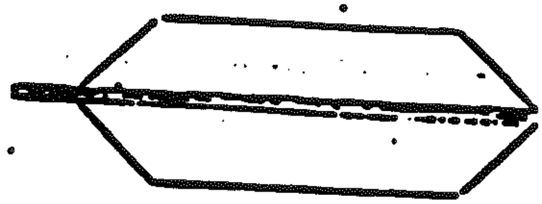
DATE December 20, 1984

FIELD VANE SHEAR TEST REPORT

TEST NO.	VS-2	**ELEV. TOP OF HOLE**	595.6
BORING HOLE NO.	TB-1	**DEPTH TO TEST POINT**	55.0
LINE & STA.	-	**ELEV. OF TEST POINT** (Tip of Vane)	540.6
OFFSET	-		

TORQUE ARM LGTH. 12 **IN.**
TORQUE ARM DIA. 3/4 **IN.**
VANE LGTH. 5 **IN.**
VANE DIA. 2.5 **IN.**

VANE DATA



Ultimate Shear Strength (S) (Lbs./Sq. Ft.) = $\frac{30.87}{12}$ **x Applied Torque (T) (In. - Lbs.)**

FRICTION ON VANE SHAFT		UNDISTURBED CONDITION		REMOLDED CONDITION	
Rotation (Degrees)	Force Gage Reading (Lbs)	Rotation (Degrees)	Force Gage Reading (Lbs)	Rotation (Degrees)	Force Gage Reading (Lbs)
		5	2	5	9
		10	15.5	10	10
		15	25	15	11
		20	28	20	11.2
		25	27	25	12
		30	25	30	12
				35	12.5
				40	12

Re
de
45
50
55

READINGS & CALCULATIONS	UNDISTURBED CONDITION	REMOLDED CONDITION
Maximum Force Gage Reading for Vane (Lbs)	28.0	12.5
Maximum Force Gage Reading for Shaft (Lbs)	-	-
Net Force (Lbs)	28.0	12.5
Applied Torque (T) = Net Force x Torque Arm (In-Lbs)	336.0	150.0
Ultimate Shear Strength (S) = $\frac{1}{AF}$ T	864	385

Sensivity = $\frac{\text{Shear Strength (Undisturbed)}}{\text{Shear Strength (Remolded)}}$ = 2.24

Natural Water Content 21.7% (Sample PS-3) **Half-Unconfined Comprehensive Strength** 580 **Lbs./Sq. Ft.**

TECHNICIAN LK **CHECKED** BLF

Comments Increase shear strength by 3% to 890 psf based on Bjerrum's correction factor. (Ref.1).

Project No. 84185 NEYER, TISEO & HINDO, LTD.

Project Allen Park Clay Mine Landfill

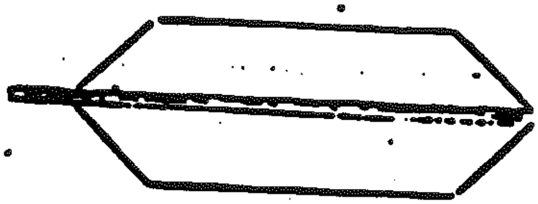
Location Allen Park, Michigan DATE December 20, 1984

FIELD VANE SHEAR TEST REPORT

TEST NO.	VS-3	ELEV. TOP OF HOLE	595.6
BORING HOLE NO.	TB-1	DEPTH TO TEST POINT	70.0
LINK & STA.	-	ELEV. OF TEST POINT (Tip of Vane)	525.6
OFFSET	-		

VANE DATA

TORQUE ARM LGTH. 12 IN.
TORQUE ARM DIA. 3/4 IN.
VANE LGTH. 5 IN.
VANE DIA. 25 IN.



Ultimate Shear Strength (S) (Lbs./Sq. Ft.) = $\frac{30.87}{12}$ x Applied Torque (T) (In. - Lbs.)

FRICTION ON VANE SHAFT		UNDISTURBED CONDITION		REMOLDED CONDITION	
Rotation (Degrees)	Force Gage Reading (Lbs)	Rotation (Degrees)	Force Gage Reading (Lbs)	Rotation (Degrees)	Force Gage Reading (Lbs)
-	-	5	1.5	5	6.0
		10	5.0	10	7.0
		15	12.0	15	7.0
		20	19.0	20	7.0
		25	19.0	25	6.5
		30	18.5	30	6.0
		35	18.0		

READINGS & CALCULATIONS	UNDISTURBED CONDITION	REMOLDED CONDITION
Maximum Force Gage Reading for Vane (Lbs)	19.0	7.0
Maximum Force Gage Reading for Shaft (Lbs)	-	-
Net Force (Lbs)	19.0	7.0
Applied Torque (T) = Net Force x Torque Arm (In-Lbs)	228.0	84.0
Ultimate Shear Strength (S) = $\frac{1}{AF}$ T	586	216

Sensivity = $\frac{\text{Shear Strength (Undisturbed)}}{\text{Shear Strength (Remolded)}}$ = 2.71

Natural Water Content - % Half-Unconfined Comprehensive Strength - Lbs./Sq. Ft.

TECHNICIAN LK CHECKED BLF

Comments Increase shear strength by 3% to 600 psf, based on Bjerrum's correctional facto
(Ref.1)

Project No. 84185 NEYER, TISEO & HINDO, LTD.

Project Allen Park Clay Mine Landfill

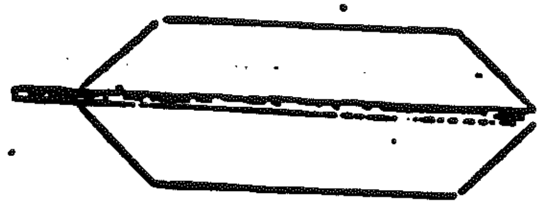
Location Allen Park, Michigan DATE December 26, 1984

FIELD VANE SHEAR TEST REPORT

TEST NO.	VS-1	ELEV. TOP OF HOLE	591.9
BORING HOLE NO.	TB-2	DEPTH TO TEST POINT	25.0
LINE & STA.	-	ELEV. OF TEST POINT (Tip of Vane)	566.9
OFFSET	-		

TORQUE ARM LGTH. 12 IN.
TORQUE ARM DIA. 3/4 IN.
VANE LGTH. 5 IN.
VANE DIA. 2.5 IN.

VANE DATA



Ultimate Shear Strength (S) (Lbs./Sq. Ft.) = $\frac{30.87}{12}$ x Applied Torque (T) (In. - Lbs.)

UNDISTURBED CONDITION Rotation (Degrees)	Force Gage Reading (Lbs)	UNDISTURBED CONDITION Rotation (Degrees)	Force Gage Reading (Lbs)	REMOLDED CONDITION Rotation (Degrees)	Force Gage Reading (Lbs)
0	0	35	33	5	8
5	0	40	33	10	9
10	0	45	34	15	9
15	2	50	34		
20	12.5	55	34		
25	22				
30	30				

READINGS & CALCULATIONS	UNDISTURBED CONDITION	REMOLDED CONDITION
Maximum Force Gage Reading for Vane (Lbs)	34	9
Maximum Force Gage Reading for Shaft (Lbs)	-	-
Net Force (Lbs)	34	9
Applied Torque (T) = Net Force x Torque Arm (In-Lbs)	408	108
Ultimate Shear Strength (S) = $\frac{1}{AF}$ T	1050	278

Sensivity = $\frac{\text{Shear Strength (Undisturbed)}}{\text{Shear Strength (Remolded)}}$ = 3.78

Natural Water Content - % Half-Unconfined Comprehensive Strength - Lbs./Sq. Ft.

TECHNICIAN D.R.V. CHECKED BLF

Comments Increase shear strength by 7% to 1120 based on Bjerrum's correction factor (Ref.1).

Project No. 54185 NEYER, TISEO & HINDO, LTD.

Project Allen Park Clay Mine Landfill

Location Allen Park, Michigan

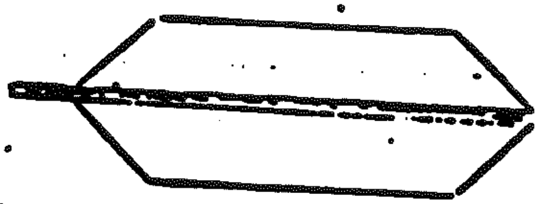
DATE December 27, 1984

FIELD VANE SHEAR TEST REPORT

TEST NO.	VS-2	ELEV. TOP OF HOLE	591.9
BORING HOLE NO.	TB-2	DEPTH TO TEST POINT	60.0
LINE & STA.	-	ELEV. OF TEST POINT (Tip of Vane)	531.9
OFFSET	-		

TORQUE ARM LGTH. 12 IN.
TORQUE ARM DIA. 3/4 IN.
VANE LGTH. 5 IN.
VANE DIA. 25 IN.

VANE DATA



$$\text{Ultimate Shear Strength (S) (Lbs./Sq. Ft.)} = \frac{30.87}{12} \times \text{Applied Torque (T) (In. - Lbs.)}$$

FRICTION ON VANE SHAFT		UNDISTURBED CONDITION		REMOLDED CONDITION	
Rotation (Degrees)	Force Gage Reading (Lbs)	Rotation (Degrees)	Force Gage Reading (Lbs)	Rotation (Degrees)	Force Gage Reading (Lbs)
		0	0		
		5	18	0	0
		10	20		
		15	20.5	5	11.2
		20	20	10	11.5
		25	19.5	15	11.5
		30	19.5	20	11.5

READINGS & CALCULATIONS	UNDISTURBED CONDITION	REMOLDED CONDITION
Maximum Force Gage Reading for Vane (Lbs)	20.5	11.5
Maximum Force Gage Reading for Shaft (Lbs)	-	-
Net Force (Lbs)	20.5	11.5
Applied Torque (T) = Net Force x Torque Arm (In-Lbs)	246	138
Ultimate Shear Strength (S) = $\frac{1}{AF}$ T	633	355

Sensivity = $\frac{\text{Shear Strength (Undisturbed)}}{\text{Shear Strength (Remolded)}}$ = 1.78

Natural Water Content - % Half-Unconfined Comprehensive Strength - Lbs./Sq. Ft.

TECHNICIAN D.R.V. CHECKED BLF

Comments Increase shear strength by 3% to 650 psf based on Bjerrum's correction factor. (Ref.1)

NEYER, TISEO & HINDO, LTD.

CONSOLIDATION TEST

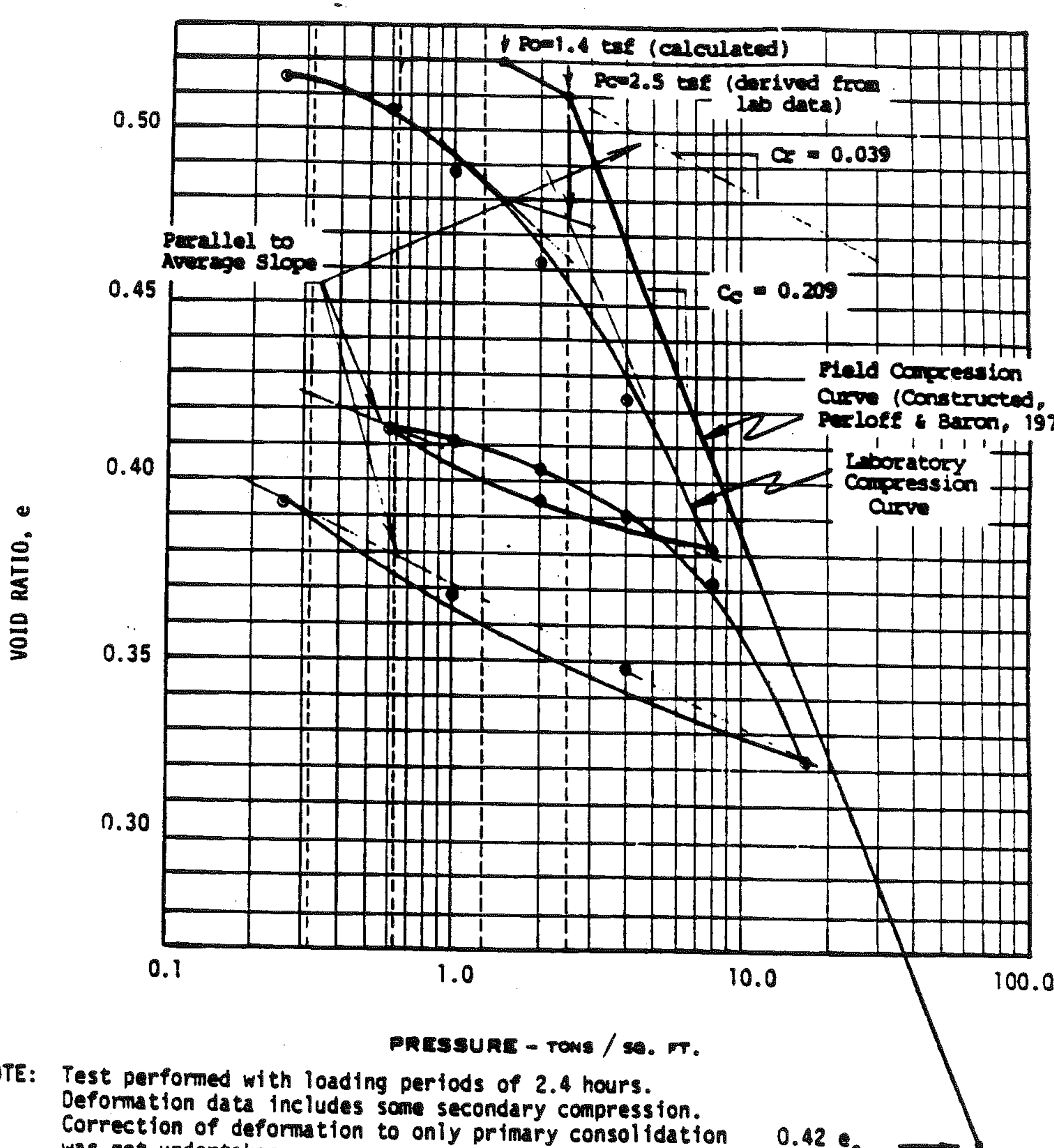
LAB SAMPLE # - PROJECT NO. 84185 OW SHEET 1 OF 1

FOR Allen Park Clay Mine Landfill DATE 1/17/85

PROJECT LOCATION Allen Park, Michigan TESTED BY S.Y.

BORING # TB-2 FIELD SAMPLE # PS-1 SAMPLE ELEV. (TIP) 541.4 CHECKED BY BLF

Sample Dia. 2.50 inches



NOTE: Test performed with loading periods of 2.4 hours. Deformation data includes some secondary compression. Correction of deformation to only primary consolidation was not undertaken.